THE EARLY DIAGNOSIS OF TUBERCLE

CLIVE RIVIERE

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THE EARLY DIAGNOSIS OF TUBERCLE

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PREFACE

The appearance of a new edition must always be hailed by the author as a welcome opportunity for revision and expansion, and neither of these methods of improvement has suffered neglect on the present occasion. Whole sections of the book, especially those devoted to physical signs, both in adults and children, have been practically rewritten, others have been notably augmented, and, in addition, much entirely new matter, including fresh illustrations, has been introduced under various headings, both old and new. In particular there appears for the first time a fairly adequate account, based on the writer's personal observations, of that important but little recognised condition, hilus tuberculosis in the adult, of which there exists, up to the present, no satisfactory description in the literature. Notwithstanding these changes the volume has grown but moderately in bulk, and will be found to still retain the handy proportions which were a commendable feature of the first edition.

Queen Anne Street, W. 1.
January 1919.

PREFACE TO FIRST EDITION

Public demand for the suppression of tuberculosis has called attention to the need, hitherto somewhat neglected, for study on the part of the profession of all measures directed to its early diagnosis. Especially urgent is the call for the detection of such forms as are common, and tend to the spread of disease, and that at a stage when the condition is still within reach of arrest or cure. In the present volume the writer has confined his attention, so far as possible, to this requirement, and attempts to supply the essential elements of diagnosis in the two conditions where it seems most urgently needed—in early pulmonary tuberculosis of adults, and in tuberculosis of thoracic glands and hilus tuberculosis in children.

In each, early detection may save from danger to the individual; in each from danger to the community, since it may lead to the prevention of 'open' lung disease through which the germ is likely to be spread. The skill required for the early diagnosis of tubercle is, unfortunately, difficult and laborious to acquire, and no short cut to it does, or ever can, exist—the path of experience must be duly trod. The way can, nevertheless, be greatly smoothed by a careful piecing together of the scattered stones of knowledge over which the journey lies, and this has been attempted in the present book. If it speeds the step of the worker somewhat towards his goal the aim of the writer will be amply fulfilled.

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PART I. ADULTS

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INTRODUCTION

Phthisis is essentially a disease of intermittent course —the first beginnings are generally overlooked, or are passed over as a febricula, or are labelled influenza, and subside again without arousing suspicion; hence it has nearly always reached a diagnosable stage by the time the physician is called in. This is true even of cases beginning with hæmoptysis—even here physical signs are generally present to skilled examination showing that the real onset very appreciably preceded the so-called 'initial' bleeding. It is highly important that profession and public alike should realise that the disease is diagnosable at these stages—given the needful skill. How is such skill to be acquired?

Doubtless such skill depends in the main on two factors—on the natural equipment, both mental and manual, of the physician, and on the amount of time he can devote to the acquirement of the technical dexterity and special knowledge needed to carry out delicate manipulations and interpret the results. No mere thumping of the chest wall and resting of an ear on its surface will suffice. Year after year our store of knowledge and wealth of technique have increased, but alas! no growth has occurred in the leisure of the practitioner whereby he can find time to keep pace with increasing demands. This has perhaps tended towards the popularity of certain special methods and laboratory tests which involve little labour to the busy practitioner, and bear about them something of the glamour of

science and the romance of novelty. So far from advancing the art of diagnosis this tendency has, in the writer's opinion, rather helped to retard the same; for it has fostered neglect of the older methods of physical diagnosis —methods on which we must still rely, and which demand for their successful application the experience which only constant practice can give. At the same time the newer methods, so attractive by reason of their atmosphere of science and modernism, are often, at the present time, very seriously misapplied.

The misguided enthusiasm of a few individuals, and lack of acquaintance with contemporary foreign experience, misleads many as to the actual value of some of these tests, and the position they should take in diagnosis. Valuable though they undoubtedly are, they yet can in no way enable us to dispense with older methods; the need must be emphasised, no less than heretofore, of fully mastering the subtleties of physical examination and especially of bringing it, in certain particulars to be noted in this volume, thoroughly up to date. But not only is the acquisition of technical skill needed, but also skill in assessing the relative value of the results obtained, in setting out our evidence with impartiality, and in summing up upon it in a judicial spirit.

Knowledge is also needed of the application and worth of those newer methods with which recent years have supplied us so that they can be used with profit. Especially is this the case with such methods as X-ray examination and the use of the tuberculin tests: both of considerable value in their right place and when properly used, but both liable to misinterpretation when knowledge of their fallacies, and especially knowledge of the varying normal, is absent or imperfect. This imperfect acquaintance with normal conditions is doubtless the most subtle and far-reaching danger with which we

have to contend. How many scientific observations have been wrecked on this familiar rock, whose presence seems less often in the minds of investigators than of their critics! How valuable seemed a febrile reaction to tuberculin—till it was demonstrated in 50 per cent. of the clinically sound! how striking are right apex phenomena, root-shadows on a skiagram, fever after exercise, and the like—till their existence as part of the varying norm is brought fully into view!

In nearly all our signs and tests the absolute is wanting; the changes on which we have to rely are comparative only and need most judicial weighing. For this our one indispensable need is a knowledge of our weights—of the normal against which disease must be balanced. And this is the case no less with the ordinary signs discovered by physical examination than with the special tests. If any skill in the signs of chest disease is to be acquired, no opportunity of studying the normal in all its manifold and subtle variations must be lost. The writer does not hesitate to ascribe the most part of any skill or knowledge in chest examination he may have acquired to the fortunate opportunity he had for many years of examining large numbers of healthy chests at all ages both in children and adults. By such means, and such means alone, can a standard be set up against which our signs may be measured and duly assessed at their fair value.

The aim of the present book is to present shortly and clearly the points whereby an accurate technique in the various methods may be acquired; to put forward such aspects of the normal as are likely to suggest or simulate disease, and point out where pitfalls are likely to arise; to describe the symptoms and signs of early tubercular disease in so far as these are of diagnostic value. In addition there will be added the various special tests—some old, some new—and indications given of how they

should be applied in the diagnosis of tubercle. Such tests fall into two groups according as they tend to discover physical changes—the X-rays, or biological changes, whether specific—the tuberculin reactions, or non-specific—the fever tests. These, as will be said, should be used one and all with a definite end in view, according as the evidence fails on the physical or biological side of the problem. Some attempt will also be made to indicate, as practically as possible, which parts of the puzzle are lacking, and are needed under various conditions, to complete the picture of tuberculosis which is requisite to the attainment of a final diagnosis.

CLINICAL DIAGNOSIS

SYMPTOMS

Symptoms in pulmonary tuberculosis are of importance from two points of view—firstly, it is through them that we must be led to a suspicion of the disease—the essential first step in its diagnosis; secondly, they supply an answer, more potent than all biological investigations, to the pertinent question, "Is the condition at the present moment active?", and this whether in cases of newly discovered, or in those of long standing, and arrested or healed, disease. This second point touches us nearly, for it is with active tuberculosis that the physician is essentially concerned, but it is to the first point, the rôle of symptoms in diagnosis, that we must direct attention at the present moment.

Though the symptoms alone will not suffice for diagnosis, yet it must be through these that suspicion is first aroused and the patient led to consult a physician. Through these also must the attention of the physician be directed into the right channel, and he cannot afford to neglect the evidence which an accurate history alone can give. As Pottenger truly remarks, "the first and most important point in the diagnosis of phthisis is to know when to suspect it;" without such suspicion the equipment of the physician is likely to avail him but little—the disease in its early stages will remain undiagnosed. In most cases of phthisis, fortunately, symptoms are found on inquiry which point towards the

chest as the centre of disease; nevertheless it may well happen that at the outset attention is drawn into other channels, and it behoves the physician to familiarise himself with the common modes of onset, and especially those most likely to lead him astray.

Modes of Onset

The two commonest and most characteristic modes of onset are those generally spoken of as the **catarrhal** and the **insidious.** In the former of these the patient is attacked by a series of 'colds,' or complains of bronchitic seizures. More rarely, as in the case recorded on page 89, the disease begins with a well-marked 'asthmatic attack' which may for long obscure the diagnosis. Influenza is credited with starting the trouble in many cases; in some this is truly so, in others the symptoms of early tubercular infection are mistaken for that disease. The insidious onset is common, and likely to carry the patient far into the disease before advice is sought. At the beginning he appears only to be 'run down,' and applies himself to tonics; later on appear symptoms which point to trouble in the lungs. Somewhat similar to these cases at the beginning, but worthy of a separate grouping, are those with **neurasthenic symptoms,** where nervous depression, insomnia, and gastric disturbance present a striking picture. This is an important group to recognise, since neurasthenia is likely to be diagnosed, and neurasthenia it really is—but of tuberculo-toxic causation. Cases which develop with **anæmia,** and in which this remains, for a while, the most striking symptom, may also be mentioned here as likely to lead to error. They occur especially in young girls, and no chlorotic patient should be passed over without examination of the lung apices. A **hæmoptoic onset** is striking, and little likely to be overlooked; it is, however, important to recognise the

fact that no further symptoms may appear for years, and yet the disease be smouldering unsuspected. An onset with **pleurisy** also forms, as a rule, a striking picture, and here again disease may remain quiescent and lull suspicion for years after the pleural attack. These two conditions will receive further attention hereafter (pp. 11 and 13). An onset with **fever and rapid pulse** may occur, and these be the first symptoms leading to suspicion of disease. In some cases tachycardia and palpitations on exertion may occur without fever, or the pulse rapidity be out of all proportion to the thermometric change. **Dyspepsia** is common at the outset, either as the main complaint or associated with others more striking; its form varies and it has no very characteristic features, but it is often of the flatulent type and associated with anorexia. **Laryngeal** symptoms, a ready tiring of the voice and, later, hoarseness and aphonia, may first call attention to tubercular disease already planted in the lung, but giving symptoms at an early stage in the larynx.

Indications for Chest Examination

Having considered, in outline, certain characteristic modes of onset, it remains to review the symptoms in general from the standpoint of diagnosis. For this we require to call attention to those symptoms which are sufficiently suspicious to indicate the need for immediate examination of the chest; in other words, the most characteristic symptoms of phthisis in its early stages.

1. **Cough**: the possible varieties of cough call for no comment here, for, though to the trained ear certain kinds of cough are characteristic of the condition causing them, it is best not to presume that even with experience an examination of the chest can ever be safely omitted. It is important to bear in mind that cough may be absent at the onset of pulmonary tuberculosis,

or at least so inconsiderable as to be denied by the patient.

2. **Wasting** : of which, in early adult life, tuberculosis is the most important cause.

3. **Hæmoptysis** : a symptom of such importance from the point of view of diagnosis as to stand apart from all others and claim a separate description (p. 11).

4. **Hoarseness** : which may be due to simple laryngeal catarrh, common in pulmonary tuberculosis, or may be evidence of tuberculous infiltration.

5. **Dyspepsia** : which in phthisis presents no distinctive characteristics, but varies greatly in its nature and is often associated with malnutrition. Very commonly it presents a picture of distension after food, with epigastric discomfort or pain, and constipation.

6. **Fever** and **rapid pulse** : demanding an explanation, when tuberculosis may be the correct one. " Tuberculosis without tachycardia, or at least instability of the pulse, is exceedingly rare," remarks Fishberg. A pulse persisting at 90–100 in absence of fever may arouse suspicion of early disease.

7. **Sweating, chills** and influenza-like symptoms, often attributed wrongly to Pfeiffer's bacillus. In addition may be mentioned **pains** in the chest, often round the shoulder, or rheumatism in limbs or joints varying from mere vague pains to definite arthritis, probably of toxic origin. These pains are unrelieved by salicylates but may improve on tuberculin treatment.

8. **Anæmia.**

9. **Protracted convalescence** from other diseases, and especially from the infective fevers of the young.

10. **Family history,** and therewith must always go **exposure to infection,** is worthy of investigation, but we must not be hypnotised by information obtained under this heading. The importance of exposure to infection in adults can easily be over-estimated. Indeed,

it is probable that household infection will rather confer immunity than the reverse in those of mature age, though gross infection in infancy or early childhood may very likely determine the outbreak of tuberculous disease at puberty, or in early adult life.

Hæmoptysis

Notwithstanding all that has been written to the contrary, there is generally in practice but little difficulty in deciding whether blood comes from the respiratory passages or from elsewhere. It generally appears with cough, though at times this is slight, is frothy, bright red in colour and, most important evidence, is nearly always followed for a few days by sputum mixed with blood streaks or small clots. If a large quantity comes up it may be swallowed and vomited, but this is less likely to occur in an initial hæmoptysis than in one occurring at a later stage of the disease. Blood from the upper air passages, from spongy gums, or nose bleeding, is usually easy to exclude. Streaks of blood in the sputum are not uncommon in cases of chronic bronchitis and other lung conditions, and blood in this amount has no significance. The conditions other than phthisis most likely to cause hæmoptysis in large amount are mitral stenosis, aortic aneurysm, and bronchiectasis with or without fibrosis of the lung. The last of these is but too little recognised as a source of bleeding, especially in young people.

Other causes of pulmonary hæmorrhage, among which the more common ones given above are included, may be conveniently classified as follows :—

1. **Blood diseases.** Severe anæmia, purpura, leuchæmia.

2. **Disease of heart or vessels.** Mitral disease, embolism and infarction of lung, aortic aneurysm.

3. **Disease of lungs or bronchi.** Any ulcerating

process, as bronchiectasis, abscess, gangrene, actinomycosis, fœtid bronchitis, cancer, syphilitic ulceration of trachea or bronchi.

Care must be taken in examining the chest after a hæmoptysis not to fall into the error of attributing all the moist sounds present to tubercular disease. A very false notion of the size of a diseased area may be obtained if time is not given for these temporary adventitious sounds to disappear.

Frequency of hæmoptoic onset. Barnes found hæmoptysis the initial symptom in 15 per cent. of cases; Bonney in 20 per cent. among 546 cases; Bartlett in only 6 per cent. among 400 cases. The great value of the initial hæmoptysis is that it brings the patient to his physician at an earlier stage than would otherwise occur. This is not to say that it brings him before physical signs are present; it is the writer's experience that in most cases it is already possible to demonstrate lung changes where a so-called initial hæmoptysis has occurred.

Diagnostic value. The value of a well-marked hæmoptysis is so great as to make this symptom, when well authenticated and other causes can be excluded, well-nigh pathognomonic of tubercle. This may be said notwithstanding the occurrence of cases where no other signs of disease ever appear. We know how often evidence of old disease is found on the post-mortem table, and it is certain that occult lung disease progressing to arrest or cure is commoner than many of us believe. Lord, among 1,381 post mortems at the Massachusetts General Hospital, found fifteen such cases where a hæmoptysis without subsequent illness had occurred at some time in their past. In fourteen of these pulmonary tuberculosis was found to have been the cause, and the fifteenth was due to syphilis. It is, then, of the utmost importance that with a free hæmoptysis (other causes

being excluded) phthisis should be presumed, and the patient be treated for this disease until the risk of extension can be definitely excluded. As has been already said, the diagnosis of phthisis can generally be confirmed in these cases from physical signs in the hands of those who have had opportunities for special experience.

Pleurisy

The more delicate have our methods of investigation become, the higher is the percentage of idiopathic pleurisies proved to be tubercular. Indeed Jousset, by his digestive method, claimed to have found the tubercle bacillus in every one of twenty-three effusions investigated. Other observers have failed to obtain such striking results, but still it is generally admitted that the large majority of these cases, whether with or without effusion, are of tubercular origin.

Not only is pleurisy of tubercular causation but it is also followed in a large number of cases by pulmonary disease. In some cases, no doubt, a lesion already existed in lung or glands, but it must be remembered also that the lymphatics of the pleura pass to the root glands, and these will be readily rendered tuberculous and hand on infection stage by stage to the lung itself, after the manner described on p. 229. The relationship of pleurisy and phthisis is well brought out in an investigation conducted by Allard and Koester. Among 2,123 cases of phthisis, a history of idiopathic pleurisy was obtained in no fewer than 650: on this inquiry we confess that we should place but little reliance. Most important, however, is the fact that of 514 cases of pleurisy with effusion, followed up over a number of years, no fewer than 47·7 per cent. developed pulmonary tuberculosis. Even after dry pleurisy 42 per cent. of cases developed lung disease subsequently. The number was much

smaller in childhood than after pleurisy in later life; in patients developing pleurisy between the ages of 31 and 35 no fewer than 60·4 per cent. afterwards suffered with phthisis. In most cases (85 per cent. of the total), symptoms of pulmonary disease develop within five years of the pleurisy; after that interval is passed the likelihood of disease occurring appears to be small.

Conclusions. Two conclusions of value in the diagnosis of phthisis are deducible from the above.

1. Idiopathic pleurisy must be considered strong evidence of the presence of tuberculosis in lung or glands, or that such disease is likely to develop subsequently; a radiogram will often serve to complete the diagnosis in this respect. In addition a careful physical examination of the chest, especially at the apices, must be made, but with due precaution against certain fallacies. Thus, in presence of an effusion, râles in the opposite lung, even at the apex, must not be considered conclusive evidence of tuberculosis, since this lung is often the seat of hyperæmia and œdema. Further, hyperresonance of the relaxed lung tissue above the effusion may give a false impression of impairment to percussion over the opposite side. These pitfalls have only to be recognised to be avoided.

2. The chances being even whether such a pleurisy will be followed or not by pulmonary tuberculosis, it is necessary to keep such cases under close observation, especially during the first five years following the attack.

And now having arrived, by means of the patient's account of his symptoms, supplemented by his replies to certain leading questions, at a provisional diagnosis, or at least a suspicion, of tuberculous disease, it is necessary to pass on without delay to certain special tests which may confirm and enrich the evidence from symptoms, and thus carry the case a stage further on

the road towards a complete diagnosis. In the first place the **weighing machine** must be called in as a check on the patient's history of loss of flesh; in the second place, more vital still and too often neglected, a **temperature chart** must be kept for a full week after the manner advocated on p. 174. Finally, repeated **sputum examinations** will have to be undertaken, in case this, the final test of tuberculosis, should chance to supply a solution. In the meantime the physical signs will be under investigation, and we naturally turn to these as the next stage in the diagnosis.

PHYSICAL SIGNS

In spite of the notable discoveries of modern medical research in the serological and bio-chemical fields, it must be insisted that the physical examination of the chest still remains the broad highway towards the diagnosis of pulmonary tuberculosis. Nor has progress been lacking in this latter domain of work any more than in the former, for many of the older methods have been amplified and improved, and valuable new ones have been introduced. Indeed, a complete routine physical examination of the chest has already become a prolonged and exhausting proceeding, and bids fair, in the near future, to rank in the category of the "major operations." Since, therefore, the strength and endurance of the patient, and the time of the physician, are no inexhaustible quantities, some curtailment will generally be needed to reduce the proceeding to more endurable proportions. The question of which, among physical signs, may be discarded as redundant, and which must needs be retained as essential, will differ somewhat with the special aptitudes and training of the individual physician. Thus some, with a passion for detail, will

exhaust their time and the patient's strength in a prolonged auscultation of the chest—nothing less than a hundred forced respirations with coughings interspersed will satisfy their needs! Others, the writer amongst them, prefer to rely on a less detailed survey over a more extended field of observation. In this connection it may fairly be urged that the special tests, such as the determination of Krönig's isthmus, consume but little time in practice, and yet supply information of a very definite nature. The writer's routine proceeding in the physical examination of a chest is commonly on the following lines:—

Firstly, inspection—only a rapid and comprehensive glance; next, percussion for 'reflex bands' (p. 34) over the back; then a return to the front of the chest with 'contrast percussion,' followed by auscultation, over the two lungs, some seven to nine points over each being examined and compared (pp. 46 to 61); afterwards percussion up one or both sides of the chest from base to apex (p. 30), ending with a mapping out of parasternal dulness (pp. 97 and 240). At the finish of this proceeding, auscultation after cough (p. 49) at the apices and below the clavicles, or sometimes this is left till after the back has been examined. Next the whole proceeding is repeated for percussion and auscultation over the back, not omitting the determination of the paravertebral dulness (pp. 97 and 246) on each side. At this stage, before leaving the back, the writer is accustomed to examine and compare the movement of the two sides with a hand over each shoulder after the manner described on p. 45. Finally, Krönig's isthmus (p. 68) is marked out and measured at the top of each shoulder in front, and the tidal excursion (p. 73) determined at the sides and perhaps behind. Having got so far, very definite information will have been accumulated, and, if the patient's endurance permits, a return is made to such

points, eommonly auscultatory, as seem likely to supplement this, and further eonfirm the diagnosis. The heart is either examined with the front of the chest, or is left to the end of the proeeedings. By the time this abbreviated but sufficient routine has been carried through the patient is usually getting "stale," and further examination will supply but little information of value.

The Position for Examination

A few words are needed on the position the patient should assume during examination, sinee this is of the utmost importanee. And first it must be insisted that no skilled examination of a ehest, and espeeially no just eomparison of the two sides such as is essential for the discovery of early signs of disease, is possible with a patient lying in bed; he must be standing, or sitting on a high stool, so that the examiner ean get direetly in front of and behind him. The whole ehest must be uncovered both front and back, and no assurance can be plaeed on early signs apart from this; the elothes must be seeurely fastened at the waist, so that no muscular eontractions are needed to hold them in plaee. The shoulders must be dropped well forward and the chin well down, the gaze being eonveniently directed towards a button on the examiner's waisteoat. The whole pose must be one of eomplete muscular relaxation. For examination of the baek, this position is only ehanged by the patient dropping head, shoulders, and arms as far forward and downward as they will go, so that the spines of the vertebræ projeet, and the scapulæ slide outwards and expose as mueh of the thoraeic wall as possible. The eorreet position is suggested in the accompanying drawings (pp. 18 and 19).

It may be thought that the attention here given to the proper position for examination is a point unduly

Fig. 1.—Examination Posture: Front.

Fig. 2.—Examination Posture: Back.

laboured. This is, in the writer's opinion, far from being the case, since a faulty pose will readily produce signs which closely simulate those of disease. That this is not sufficiently recognised is evidenced by the frequency with which one observes the chest examined in impossible attitudes—with one or both braces still on, or with the clothes slipping off the hips and held up by muscular contractions, or with one or both shoulders raised and thrown back, or in various other positions of muscular and postural asymmetry.

INSPECTION

At the outset of a lung examination it is well to fix the apex of the heart and to auscultate this organ. Thereby organic disease, especially mitral stenosis, is immediately excluded before passing on to the lungs.

The **shape of the thorax** will be the first thing to claim attention, and it must be noted that in phthisis the chest is commonly of normal shape and size, and may even be over-extended. A flat chest is said by some to be suggestive of disease, but this point is of no value in diagnosis and its consideration belongs rather to the subject of prognosis. The so-called "habitus phthisicus," associated with a long, narrow, flat thorax with acute epigastric angle, sloping shoulders, and winged scapulæ, and also with signs of defective nutrition, may be found in phthisis—but also without evidence of this disease. Its occurrence amongst ordinary cases with definite lung tuberculosis is strikingly uncommon. On the other hand, Fischer (quoted by Röpke), among 11,000 phthisical Prussian soldiers found one-fourth with a history of heredity, and among these no less than 75 per cent. had a marked "paralytic thorax." Whether such an appearance should be looked upon as pre- or post-tubercular still remains a matter of opinion, but the writer would strongly incline to the latter view.

Pollack, indeed, claims to have watched the development of this change as the result of severe but recoverable tuberculosis in infancy, and the writer can record a similar experience. As a foil to this may be mentioned the emphysematous chest sometimes left behind after an attack of pulmonary tuberculosis. The mere shape of the thorax is of but little value to us in diagnosis; we shall note this and pass on to the more important point of asymmetry or flattening, evidence of inequality between the two sides.

Asymmetry and Flattening. This must be looked for in a good light. Flattening of an apex, the point of most importance, may be due to many causes other than lung disease—spinal curvature leading to rotation of vertebræ and a dorsal hump with corresponding flattening in front; wry-neck; congenital absence, not very uncommon, of parts of the pectoralis or trapezius muscle. In addition there may be flattening or even hollowing of an apex in health without any discoverable associated cause. Flattening in phthisis is hardly an early sign, and inspection never gives more than indications for further investigation. Inspection of movement will be studied together with palpation after percussion is completed (p. 45); it is best to percuss before the condition of the lungs is disturbed by forced respirations.

PERCUSSION

The practice of percussion was introduced by Auenbrugger in 1760; that is, over 150 years ago. Auenbrugger used direct percussion with his gloved finger-tips, and it was not till 1826 that "mediate" percussion appeared through the introduction of the pleximeter by Piorry. Thereafter flourished what might be termed the "era of heavy percussion," the art being dominated by the unfortunate belief that forcible percussion was

necessary to disclose all but surface changes in the lung. But as early as 1875 we find C. A. Ewald recommending the very lightest percussion (schwellenwert perkussion) for outlining the cardiac dulness, using his finger as pleximeter, and applying his ear close to the percussed surface. This manœuvre he based on the physical law that the smaller the stimulus the slighter will be the change in it which can be sensed—he so percussed that the note over dull areas was practically absent, with the assurance that the difference between this "nothing" and resonance is more readily detected by the ear than that between resonances of different amount.

In 1885 W. A. Gairdner published his views on the value of a "minimised percussion stroke," particularly in the outlining of organs—views which he had taught to his students in Glasgow for many years previously. He pointed out that "deep percussion is necessarily inexact percussion, and what you gain in volume of sound by strengthening your stroke, you lose, and far more than lose, in definition." He laid the blame for heavy percussion on Piorry, who too sharply separated superficial and deep percussion, as if each were equally accurate in limiting organs, and it was only a matter of "depth." Gairdner was far from optimistic as to the possibility of any accuracy in defining the outline of organs even half an inch below the surface.

In articles published in 1889 Krönig gave endorsement to the views in favour of light percussion. In 1899 Turban remarked that "ordinary percussion of the lung should be light and carried out during shallow breathing." He insisted on the wasteful futility of the heavy percussion stroke; "the acoustic influence of heavy percussion is felt far more in breadth than in depth, and on this account observation of parts lying vertically under the percussed spot is rendered uncertain by the vibration of laterally adjoining tissue containing

air. It seems also to be recognised that the lightest percussion producing a note gives an acoustic wave sufficient in depth for determining relative heart dulness and similar data, without the disturbing lateral factor."

In spite of these eloquent voices the practice of gentle percussion appears to have made little headway in the years following. The writer's student days are filled with the recollection of "two-finger," "three-finger," and even "whole-hand" percussion, though doubtless there existed, in certain medical circles, those who practised a more enlightened method.

In 1905 Goldscheider began to insist on the value of gentle percussion for determining, not only superficial, but also deeper, changes in the lung. The power of soft percussion to penetrate deeply was demonstrated by Moritz and Röhl in 1907, in experiments with a porous gelatin cylinder, and also on the dead lung by Goldscheider.

Of recent years the value of gentle percussion for the appreciation of both superficial, and also of deeper, changes in the lungs has received more general acceptance. In the detection of early tuberculous disease in the lung, its acknowledged value seems likely to produce far-reaching changes, for whereas formerly percussion took only a poor second place in the detection of early phthisis, percussion in skilful hands seems likely to compete with auscultation for a front place in diagnosis. It is the writer's experience that some alteration to skilled percussion can be found over every diagnosable lesion, and that a diagnosis of phthisis can never be safely made without it. This is not to deny that very early changes may be, in some cases at least, auscultatory; but the slight alterations of breath sound in which these consist cannot suffice for a diagnosis apart from other positive evidence, and this evidence is usually first obtainable by percussion. In very many cases, more-

over, a change of percussion note precedes any auscultatory evidence of disease, and is less open to other interpretation than are the changes in breath sound which represent the earliest auscultatory signs. Lastly, and most important of all, as the writer hopes to demonstrate hereafter, it is reserved for percussion to exclude the presence of active tuberculosis in cases where this has been wrongly suspected (see p. 42).

An interesting research was carried out by Goldscheider, with the help of Levy-Dorn, into the correspondence of ordinary percussion, gentle percussion, and auscultation with the evidence given by Röntgen rays in cases of suspected phthisis. They found that gentle percussion discovered disease, confirmed by X-ray diagnosis, in many cases where ordinary percussion failed (thirty-eight cases), and that where ordinary percussion discovered changes at one apex, gentle percussion was able to demonstrate disease, confirmed by X-rays, at both (forty cases); thus demonstrating that cases are not missed by gentle percussion which to ordinary percussion would have been overlooked. Finally, they found that, though auscultation gave better results than ordinary percussion, yet gentle percussion discovered disease in a quarter more cases (twenty-two patients) than did auscultation. Von Romberg of Tübingen carried out similar research on six hundred cases in conjunction with Schlayer and obtained similar results.

Though it may be argued that fallacy might arise from greater skill of the investigator in percussion than in auscultation, yet these results are striking and would probably apply to all save a few specialists laboriously trained in the auscultation of early signs.

Aufrecht upholds the importance of percussion which he says "offers positive information much sooner than auscultation," which latter is useless to ensure a certain diagnosis. C. Minor also agrees in its value if it is skil-

fully performed. Krönig says it is "a very widespread error to expect to find the earliest physical signs by auscultation." He points out that an auscultatory change depends on the lesion coming into direct relation with the air stream, and this may not occur. Furthermore, if it does so, obstructed air entry over small areas is obscured by compensatory emphysema, and it is only when the disease has broken into the air tubes, or involves so large an area as to cause weak breathing, that undoubted signs appear. The writer's experience conforms with these views. Fishberg remarks, "We must bear in mind that phthisis does not begin as a catarrh of the small bronchi as some believe, but is an infiltration, transforming the normal porous air-containing and resonant lung into solid non-resonant tissue. At this stage the alveoli are filled with exudate, or the interstitial tissues contract and compress the alveoli, finally obliterating them altogether. Inasmuch as altered breath sounds and râles can only be found in the pulmonary apices when œdema and secretions interfere with the entry or exit of the air-current while passing through the air vesicles and bronchioles, it is clear that auscultation may not give any information at an early stage."

In this country D. B. Lees has been the exponent of percussion and has called attention to the value of systematic mapping out of the chest. W. Ewart also agrees that percussion signs precede auscultatory in phthisis, except in the catarrhal form of invasion. Though accomplishment in auscultation must not be neglected, yet there is little doubt that gentle percussion, too little practised hitherto, is the easier to master of the two methods, and yields more certain and fruitful results.

How to percuss. The best method of percussion to adopt for practical purposes is the following: first

percuss fairly softly and, if impairment is found, increase percussion to see at what point it disappears. This proceeding gives a measure of the impairment which, if slight in amount, will only be appreciable to gentle percussion, and disappear when greater force is applied. If the impairment is not found to a fairly gentle stroke, softer and softer percussion must be tried, so as to bring out any possible difference between the two sides compared, and this must be continued till the note is only just audible. The most delicate changes in the percussion note only appear at this point. "It is a good general rule," says Sahli, "that we should percuss as lightly as possible, and a good criterion of the desired strength is to evoke practically no note over the dulled areas." The comparison of the two apices is greatly facilitated, in a difficult case, by first marking out Krönig's area of resonance on the two sides (p. 69), and contrasting them by percussion.

An advantage of gentle percussion not yet referred to, is the greater opportunity it gives for the perception of slight differences of resistance over areas of impairment. The utilisation of tactile sensations to supplement, or even displace, the auditory, may be employed consciously, as in Ebsteins' 'touch percussion'; more commonly sensations of resistance record themselves half unconsciously in the general estimate of the results of percussion. Goldscheider and his followers lauded the auditory changes to the exclusion of the tactile; certainly the latter are, as a rule, of little value in the diagnosis of early pulmonary tuberculosis.

Skilled percussion can only be acquired by practice, and by many it is not acquired at all, and that in spite of notable skill in other branches of physical examination. "Percussion," remarks a writer, "is either perfunctorily performed, as an aim in itself, to impress the patient, or is altogether omitted." This neglect of

percussion is no doubt largely dependent on the marked discrepancy between the methods advocated in various text-books; where the teachers disagree the tree of knowledge can hardly be expected to flourish! But the disagreement of the masters is in most cases not fundamental, and discrepancies of method are often reconcilable when carefully inquired into. A further causation for the comparative neglect of percussion, lies, in the writer's opinion, in the pernicious practice of attempting to examine tuberculous patients while still in their beds. It may be safely asserted that no just comparison of the two sides, such as is essential to the diagnosis of early pulmonary tuberculosis, can be made save with the patient directly opposite the examiner, whether in the standing posture or sitting on a high seat.

The art of percussion is of such first-class importance in the diagnosis of pulmonary tubercle that no apology need be made for giving here a few hints and warnings.

Some practical points. An equal percussion force is, perhaps, most readily assured by percussing from the wrist; nevertheless, eminent operators have recommended that movement of the percussing finger be almost entirely from the metacarpo-phalangeal joint. A single finger, the middle one, should be used, since only gentle percussion can be advocated. The pleximeter finger should be applied closely but lightly to the chest wall, and only percussed over the area of contact. Strong pressure with the pleximeter finger must be avoided, as this is apt to bring the intercostal muscles into tension, and so vitiate the results of percussion. The percussing finger must be bent to a right angle, and descend vertically, like the hammer of a piano, or the true resonance is not obtained. Corresponding points only on opposite sides of the chest can be compared.

In the comparison of percussion resonance at two points it is well to have clearly in mind what we are

going to listen for. More or less resonance is a very confusing issue, and it is best to fix attention on one of the various component parts of which resonance is made up. These are 'fulness' or amount, 'pitch,' 'quality' and 'duration;' of these the only one easy to gauge in small amounts is 'pitch.' If the finer shades of impairment are thought of merely as a rise of pitch—the production of a higher, 'sharper' note in the musical sense—the problem is greatly lightened, and changes will be readily recognised which would otherwise be missed. Particularly is this a help where 'tympany' is present, for tympany — in the lung evidence of abnormality or disease, often associated as it is with a deposition of tubercles—is apt to rank as resonance where 'fulness' and 'duration' of note are made the test. But in tympany the pitch is raised as in other forms of impairment, and thus it falls into line with these in confirmation of Auenbrugger's dictum—"Ubi sonus est altior, ibi est morbus." In recommending pitch as the best keynote to comparative resonances the writer is aware that a lack of musical ear will be pleaded by some observers. This must be admitted as a difficulty, particularly since percussion sounds are of complex musical nature, but it is doubtful whether the senses of these people will be any more responsive to the other more elusive elements of resonance. A warning must be given against the effects of 'expectation' in the comparison of two percussion notes. The ear must 'expect' an equality of pitch—if a slight rise of pitch on one side is looked for it can, in the writer's experience, be manufactured, presumably by attuning the ear for the perception of certain overtones.

Percussion in the detection of early tuberculous changes in the lungs must be gentle, for two reasons: firstly, heavy percussion elicits a higher note at the right

apex in many normal chests (see also p. 30); secondly, the finer shades of impairment are only appreciable to gentle percussion—percussion on the threshold of sound (schwellenwert perkussion). A further reason for the avoidance of heavy percussion in the detection of phthisis is the possible production of an artificial impairment by the 'lung reflex of contraction' of Abrams, a phenomenon to be presently discussed (p. 36).

Gentle percussion is of two kinds: (*a*) one in which the soft stroke is 'carried through,' whereby the depths of the lung are reached more truly than by heavy percussion; (*b*) what may be called light, 'flipping' percussion directed to the discovery of surface changes, and whereby a thickened pleura may, perhaps, be distinguished from impairment due to underlying lung.

HOW PERCUSSION OF THE LUNGS SHOULD BE CARRIED OUT

The chest must be percussed with the patient standing, or sitting on a high stool, so that the examiner can get directly in front of and behind him. The correct posture for examination, especially vital in percussion, has been already described and illustrated on pp. 18, 19. Routine and detailed percussion of the chest must be preceded by examination of the back for the 'reflex bands of impairment' to be presently described (p. 34), since if this is deferred the reflex may be unwittingly produced by percussion of the chest wall; this having been noted, 'contrast percussion' proceeds in the ordinary way as follows:—

The front of the thorax. During percussion breathing should be quiet and unrestrained—the shallower the better; if dyspnœa occasion deep breathing, care must be taken that percussion is performed

in the same phase of respiration (see Respiratory Percussion, p. 42). Opposite parts should be compared all down the chest, and the difference on the two sides noted. It must be remembered that the finer shades of impairment are only detectable by comparison, and, in consequence, it is very easy to overlook slight changes which involve both apices at once. It happens, however, but rarely that disease gives rise to impairment of equal intensity on both sides of the chest; in doubtful cases topographical percussion (p. 62) and auscultation will soon provide a solution.

At this point it may be relevant to refer to the oft-stated discrepancy between the two normal apices on percussion. To heavy percussion, undoubtedly, the right apex, for well-explained reasons, gives a less resonant and higher-pitched note, but this is in no way true for gentle percussion, to which the normal apices are strictly equal. This fact is in itself sufficient condemnation of all contrast percussion so heavy as to elicit differences of note over a healthy chest.

In carrying out the initial comparison of the two sides the examiner should stand directly opposite the patient and percuss on the tip of the pleximeter finger. The clavicles must not be neglected, and these should be tested by direct percussion in finger-breadths from within outward over the inner half. If impairment is discovered on one side of the chest, the clearer side must then be percussed from base to apex, for there may be impairment at the better apex also, though it has appeared resonant in comparison to the opposite one. This manœuvre is best carried out with the whole pleximeter finger laid parallel to the ribs, since the border line of a tuberculous process spreading from above downwards generally maintains a more or less horizontal level.

In thus percussing from below upwards it must be borne in mind that the note above the level of the second rib is normally of higher pitch than that over the chest below, so that a slight rise of pitch cannot be interpreted as evidence of disease at the apex of the good lung.

A curious phenomenon often observable in cases of phthisis is a 'transference' of impairment at first examination from the diseased to the opposite side; this occurs only where percussion has preceded palpation and auscultation, and generally disappears after a few deep breaths. It is doubtless produced by a temporary under-expansion of the better lung, the result, perhaps, of some temporary blocking of tubes by mucus or other secretions. A possible source of error at the front of the chest may be the contraction of an irritable pectoral muscle under the pleximeter finger; congenital absence of muscles, or parts of muscles, has sometimes also to be taken into account. It must further be remembered that lung resonance is no fixed quantity, but varies with the individual, and a strikingly poor note over the upper part of the lungs, amounting in some cases almost to dulness, but equal on the two sides, may be found in individuals with normal lungs, especially in the bed-ridden, and under conditions of decided malnutrition.

It must not be forgotten that, in comparing the apices, the best note may occasionally be found on the diseased side owing to the occurrence of an overlying emphysema. This is especially apt to occur with a healed or quiescent focus, and the relative impairment at the opposite apex may then lead to a false inference, until other signs are investigated. Nevertheless, it very commonly happens in phthisis that disease becomes quiescent in the original focus, and later becomes active at the opposite apex, and in this case a true transference of impairment may occur from the older side to the apex of more recent disease.

The back of the thorax. In examining the back the same proceeding should be followed as in front—an initial 'contrast percussion' of the two sides should

be followed by percussion up each side separately from the base to the apex. Examination for the reflex bands of impairment which constitute so important a sign of lung inflammation (see p. 40), and thus incidentally of pulmonary tuberculosis, will have already been carried out as a preliminary to all other lung examination. Their presence at this stage, that is after percussion of the front of the chest, would be of no diagnostic importance since such 'concussion' of the chest wall is, of itself, sufficient to produce the reflex.

A somewhat puzzling, but not uncommon, discovery in comparing the two lungs in phthisis, is a contrast impairment on one side in front, but on the opposite side behind—what has generally been referred to as 'crossed dulness.' This, probably, depends on a compensatory hyperinflation or 'relaxation' over one surface of the diseased lung, which thus becomes dull in front and hyper-resonant behind, or *vice versa*. The hyper-resonant note gives a false impression that the opposite lung is dull, and thus a doubt appears as to which is the diseased side—a doubt which other signs will, as a rule, quickly dispel.

In percussing up the back it must be remembered that the note normally rises in pitch from the base up, but so gradually as to produce no striking changes from point to point. Such changes are only met, apart from the 'ground' dulness of tuberculous deposits, at the borders of the reflex bands of impairment (Fig. 3, p. 35) or, in muscular subjects, to some extent over thick muscle layers, especially the belly of the rhomboid muscles where these cross from the dorsal spines to the vertebral border of the scapula. On the whole the muscles, unless in a condition of spasm, affect remarkably little the percussion note over the chest. The same may be said for bulging ribs in scoliosis, though decided deformity of this nature may alter the percussion resonance to an appreciable degree.

IMPAIRMENT IN EARLY PHTHISIS

'**Ground Dulnesses.**' Since tuberculous processes tend to first appear, or at any rate reach the surface, in the neighbourhood of the apex of the lung, it is on this area that attention must be concentrated in the detection of the earliest evidences of disease. But it must not be supposed that the first lesion appreciable to percussion will likely be of the nature of a tuberculous focus or infiltration; long before tuberculous changes have advanced so far, well-marked functional alterations will have been brought about at the surface by quite early disease at deeper levels. For a very small deep lesion may, and does, by its interference with those 'lines of communication,' the bronchi and vessels, cause very considerable surface changes in the nature of collapse: gentle percussion should avail to demonstrate such collapse long before it is appreciable to stethoscopic examination. "Interference with the free circulation of air within a limited area," remarks Fishberg, "cannot be readily ascertained by auscultation, because the surrounding lung vesicles act in a compensatory manner, and suck in more air. Only when the initial lesion is extensive may we find weak vesicular, or at most broncho-vesicular breathing in a circumscribed spot." But such small areas of superficial collapse cause alterations of the lung resonance which are readily demonstrable to skilled gentle percussion. Moreover, shrinkage of the apex as a whole may occur as a result of very early lesions, as Oestreich was able to show, and deep lesions are more effective in producing this result than are superficial ones. At somewhat later stages definite expanses of tubercular infiltration may be present, sufficiently near the surface to be mapped out as dull areas.

D

The surface effects of deeper lesions at the apex were well demonstrated by the observations of Birch-Hirschfeld, and also of Schmorl, that the first tubercular deposits in phthisis do actually occur in the apical bronchi, and by obstruction lead to collapse of the parts beyond. Birch-Hirschfeld carried out an exhaustive investigation on 826 cases of accidental death. Among these, thirty-two cases proved to have been suffering from commencing phthisis, and in twenty-eight of these the tuberculous lesion occupied the lumen of an apical bronchus, nearly always the posterior branch, with blocking of the lumen, and collapse, and subsequent tuberculous infiltration, of the wedge of lung peripheral to it. These results were confirmed by the work of Schmorl; Abrikossoff, on the other hand, found the disease to begin as a peribronchitis spreading both peripherally and centrally, but later breaking into the bronchus, and distributing the infection by aspiration.

The Reflex Bands of Dulness. The Author's Sign in Pulmonary Tuberculosis

If gentle percussion is applied up or down the back in a case of pulmonary tuberculosis at whatever stage, it will be found that bands of slight impairment are present at the apex, and also across the lower scapular region on both sides (see Fig. 3); but more strongly marked at the side of disease or of more advanced disease. In some cases the impairment over these areas is decided and cannot be overlooked, more often it needs a trained ear to establish its presence with certainty. The upper of these bands reaches down to the level of the junction between the 1st and 2nd dorsal vertebræ, the lower extends between the 5th and 7th dorsal spines. If the back of a healthy person be similarly explored it will be found that these bands of percussion impairment are absent (see Sources of error, p. 40).

At the time when the writer first began to take notice of these dull areas, he was obsessed by their close relation-

ship to the apices of upper and lower lobes; and for a long time he regarded them, perhaps not unnaturally, as evidences of tuberculous infiltration at these, the so-called 'seats of election' in phthisis. But, being impressed with their curious symmetry and their invariable presence on both sides, even in the earliest stages of disease, he was stimulated to investigate the matter further and with curious results. For he discovered that these bands of impairment, though absent

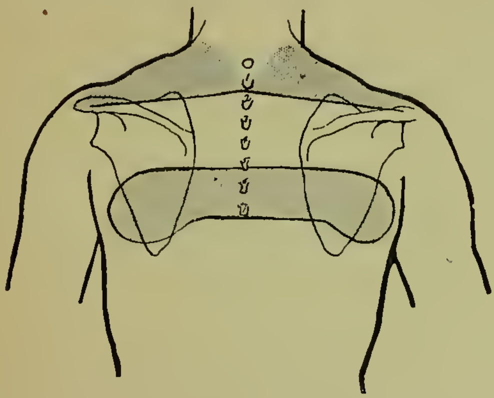


FIG. 3.—To illustrate the upper and lower bands of impairment in pulmonary tubercolosis.

in the normal chest, could yet be produced there by methods already known to him as those causing the so-called 'lung reflex of contraction' originally described by Albert Abrams. The areas thus proved to be of reflex origin, and their presence in phthisis no evidence that disease involved the four lobar apices over which they happened to lie.

Now, there are two reasons why a thorough recognition of the presence of these bands of impairment is necessary to those who hope to utilise percussion in the diagnosis of pulmonary tuberculosis.

1. Unless their nature is recognised they will almost certainly be mistaken, in some patients at least, for areas of dulness due to tuberculous infiltration, an error into which the writer was led when he first noted their presence. In certain cases of phthisis they are sufficiently marked to attract the notice even of those who have attained no skill in percussion methods.

2. Their presence or absence is, when their significance is thoroughly understood, of very notable value in the decision whether, in a given doubtful case, we are dealing with an early tuberculous infiltration or not. The reflex bands supply a valuable diagnostic sign.

The lung reflex of Abrams. Before going further into the practical aspects of the 'reflex sign' it is necessary to establish clearly its relationship to other ascertained phenomena. In 1903 Albert Abrams first described the 'lung reflex of contraction' associated with his name: in the previous year he had published a paper on the 'lung reflex of dilatation.' He claimed that when the chest wall is violently concussed with a heavy mallet and pleximeter, a circumscribed lung contraction occurs adjacent to the area struck, and lasts for a few seconds (up to 20 secs., Abrams). This contraction reveals itself, according to his description, by impairment to percussion, by visibility to X-rays, and by retraction of the lower lung border. He ascribed it to a contraction, through vagus stimulation, of longitudinal or dilator fibres in the bronchial walls—fibres shown by Aufrecht to exist in certain animals. Roy and Brown were at that time thought to have demonstrated the presence of dilator nerve-paths in the vagus, their observations being confirmed by Dixon and Brodie (see below). Abrams showed in subsequent communications that the 'reflex of contraction' could be obtained by other means than by local percussion—by concussion or sinusoidal stimulation over certain vertebral spines, by stimulation of the vagus nerve in the neck, by the use of certain nasal irritants, and by the administration of certain drugs.

Since these observations were made it has been shown by Dixon and Ransom (1912) that the broncho-dilator muscles are innervated from the sympathetic, and not from the vagus, as was formerly held. This is of interest, since adrenalin, a drug known to act by sympathetic stimulation, was found by Abrams to be a powerful producer of the 'lung reflex of contraction.' Abrams' phenomena can be readily demonstrated, and to them

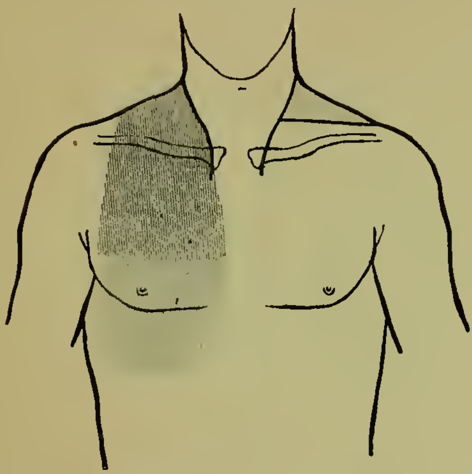


Fig. 4.—To illustrate the percussion changes produced by concussion of the chest wall below the right clavicle (Abrams' reflex), and at the same time the impairment of early phthisis. The inner line of Krönig's area is marked out, and also the anterior limit of the upper reflex band on the left side.

may now be made the following additions. Not only does impairment appear at the point of concussion, as Abrams demonstrated, and spread thence over the chest wall, but there arise over both backs, first developed on the concussed side, double bands of impairment similar to those always present in phthisis and illustrated in Fig. 3. The whole reflex can be shown to last, not a few seconds only, as Abrams affirmed, but some minutes at least.

We find, then, that in the healthy chest heavy per-

cussion, below one clavicle for example, will produce the following changes: in front, impairment over the whole side (Fig. 4), most marked at the point struck; behind, the bands of impairment already described and depicted. In the earliest stages of pulmonary tuberculosis, and also throughout the course of the disease, we find, as already explained, bands of impairment over both backs of precisely similar position, size, and shape to those obtained in the healthy by concussion. It remains to remark that in front a widespread impairment similar to that produced by concussion (Fig. 4) is very commonly present in quite early tuberculous disease, and it is tempting to believe that this also owns a similar explanation—that it is, in fact, of reflex origin just as are the posterior dull areas. For otherwise the extent of this area of impairment with incipient disease, a point on which the writer laid stress in the first edition of this book, will still remain as inexplicable as it has been in the past. "In practice it is found," remarked the writer in 1914, "that impairment in the earliest stages of phthisis, though slight in degree, is by no means narrow in extent; and the reason of this is, in the writer's opinion, not always easy of explanation. Changes of air and blood content in surface layers are doubtless important factors; pleurisy is probably a frequent cause. . . . Certainly in practice it is not uncommon to find slight impairment reaching right to the base in early stages, a distribution which, with failure of auscultatory changes, is very significant of pleural disease. There remains the possibility, not hitherto suggested, that spasm of muscle over the affected side may be an occasional factor." Whether the reflex phenomena described may be after all really myotensive, as W. Ewart suggested when discussing the writer's 'reflex sign' (*Lancet*, 1915, ii. 675 and 942), or depend on a true lung reflex as Abrams holds, remains a problem which the future must resolve. We have before us a striking fact—that the earliest percussion changes of phthisis (Figs. 3 and 4) are identical with those which can be artificially produced, as a passing reflex phenomenon, in the healthy. Can we refuse the conclusion

that these changes in phthisis are also of reflex origin, the tuberculous deposit supplying the necessary stimulus by inflammatory irritation of the lung parenchyma?

We have found, then, that at all stages, including the very earliest, of pulmonary tuberculosis there is present a slight diffuse impairment, generally most marked at the apex, over the affected side in front, and also characteristic fixed areas of impairment over both backs

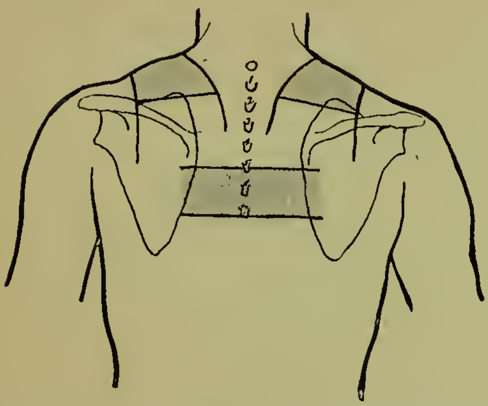


Fig. 5.—To illustrate a convenient method of finding the lower band with the pleximeter finger laid across the spine, and the upper by following up Krönig's area of resonance till the line of impairment is reached.

behind. Onto these areas become grafted, according to the extent of the disease, the 'ground dulnesses' of collapse, and of tuberculous infiltration, but it is certain that in most cases the reflex areas precede by a long while the signs due to anatomical surface changes. Whether the early impairment of pulmonary tuberculosis on which so much stress has been laid by the champions of percussion has been dependent, in the main, on these reflex bands, or on the ground dulness of disease, it is, of course, impossible to say. Certainly the writer's advocacy of percussion in the diagnosis of the earliest

stages of phthisis has been almost entirely based on the presence of these upper and lower bands of impairment.

Significance of the reflex sign. The bands of impairment are present, as already noted, in cases of phthisis at all stages, with certain exceptions to be presently noted; also in all forms of pneumonia and broncho-pneumonia. They are absent in simple bronchitis, in bronchiectasis, in purely localised glandular tuberculosis, in new growths of the lung, and in pleurisy unaccompanied by pulmonary foci, a condition of uncommon occurrence. Their presence, then, appears to denote an inflammation of the lung parenchyma, of whatever causation, for certainly there can be nothing 'specific' about a reflex phenomenon; nevertheless the value of this sign in cases of doubtful pulmonary tuberculosis is very real, since in practice the differential diagnosis generally lies between this disease and some condition where the lung parenchyma is not inflamed.

Sources of error. Certain possible causes of error must here be mentioned, since the value of the sign depends on the consistency of the evidence given by its presence or absence. The reflex is absent, as already stated, in the healthy chest, but it can be readily produced by certain apparently innocent manœuvres, and thus give rise to error. The most important of these is concussion or percussion of the chest wall, and for this reason it is necessary to look for the 'reflex bands' at the earliest stage of physical examination. It is also well to establish their presence or absence on more than one occasion, since confirmation adds reliability to a physical sign demanding some delicacy of perception. In a few cases of advanced pulmonary tuberculosis, where the power of reaction appeared to have failed, the writer has found the bands of impairment of feeble development or altogether absent. These cases are of rare occurrence, and during the three years since the

writer first described this sign he has been able to note, among a large material, only two or three exceptions to the rule that it is invariably present in cases of active pulmonary tuberculosis. The most notable source of possible error lies in the fact that the reflex is present in all marked cases of nasal disease, particularly if accompanied by obstruction. This should in all cases be looked for by getting the patient to breathe strongly through the nose, and compressing each nostril in turn. If nasal obstruction is present, and this is particularly common among Jewish patients, no significance at all can be attached to the presence of the reflex bands of impairment.

Where difficulty is experienced in deciding on the presence or absence of the percussion 'bands' certain manœuvres are of assistance. Firstly, by arresting the breathing the recurring changes of note between inspiration and expiration may be abolished, and a source of confusion removed. Secondly, by vigorous skin stimulation of the back on the side to be examined (rubbing with a piece of flannel or rubber) the whole side will be made more resonant (Abrams' 'reflex of dilatation'), while the bands of impairment remain as before. By thus heightening the contrast, the dull areas are made to stand out more clearly, so that their presence needs less skill and practice for its detection.

Practical value of the reflex sign. Excluding the sources of error enumerated in the foregoing section, the reflex sign will supply the following valuable points of information bearing on the diagnosis of pulmonary tuberculosis.

(*a*) It will draw attention to the presence of a hidden lung focus long before this becomes apparent to other clinical methods of investigation, and even, accidentally, before symptoms are present. On the other hand, and equally of importance, the absence of this sign may

enable the physician definitely to exclude the presence of a focus of active tubercle—otherwise a well-nigh impossible task!

(*b*) The absence or presence of the reflex will help to settle the question whether an apical 'catarrh,' or apical collapse, is of merely bronchitic origin, or includes a broncho-pneumonic process of probable tuberculous nature.

(*c*) It will help to decide when arrested disease has passed on to the stage of definite cure—also whether lung changes, accidentally discovered, are those of old and cured disease, or are due to an active process which has not yet led to recognisable symptoms.

(*d*) In cases of pleurisy it will help to discover whether a hidden lung focus is also present, as appears to be almost invariably the case.

(*e*) It will often assist greatly in the diagnosis between tubercle and bronchiectasis, and between tubercle and new growth of the lung.

RESPIRATORY PERCUSSION

Over the normal lung a very perceptible change of percussion note occurs between inspiration and expiration, the note becoming lower pitched as the air is expelled. During quiet breathing this change interferes but little with percussion, but it must always be borne in mind that the two sides are only truly comparable during the same phase of respiration, and this becomes especially important if the patient is breathing deeply. In cases of doubtful impairment the sides of the chest should be compared during the same respiratory phase, or with the breathing arrested.

As early as the year 1875, J. M. Da Costa had noted the fact that "a full held inspiration increases the resonance, makes the sound fuller, and raises the pitch," while a deep expiration lessens the fulness and lowers

the pitch. These changes he found absent or even reversed in phthisis, and he recommended "respiratory percussion" as a means of detecting early percussion changes in pulmonary tuberculosis. But by respiratory percussion Da Costa meant percussion at the end of inspiration, with concentration of the attention on 'fulness' of note (see p. 28). Da Costa used heavy percussion, and to heavy percussion the fulness of sound over an expanded chest is so striking a phenomenon that the accompanying alteration of pitch is but little noticed. But for those who practise gentle percussion the reverse condition obtains; fulness of note becomes negligible, and when attention is concentrated on pitch we find this is decidedly lowered during expiration and rises with inspiration. Hence, it is at the end of expiration that modern percussion tends to find the greatest resonance, and 'expiratory percussion' is the method which is here recommended. Since, however, it is an increased contrast between the two sides of the chest that respiratory percussion is designed to supply, Da Costa's method is equally admissible to those who may elect to use it.

The value of respiratory percussion depends on the fact than in disease the normal change is upset, being either reduced, suppressed, or in some cases inverted. Emphysema abolishes the change, or greatly reduces it; tubercular infiltration also alters or reduces the respiratory change of note, and this in early cases over one lung only. Where, in early phthisis, a slight rise of percussion pitch is found over one apex during quiet breathing, this change may be greatly accentuated by percussion at the end of full expiration. Since the effect of such expiration is to lower the pitch over the healthy lung but rather to raise it over the diseased lung, a difference which was perhaps difficult to appreciate is reinforced so as to be easily perceptible. The patient

is directed to let the air out of the lungs and to hold the breath while percussion is performed and the note compared on the two sides. The writer has found this manœuvre of value to himself in cases of slight or doubtful impairment, and has used it with advantage to demonstrate percussion changes to others. Observers who fail to recognise a change to ordinary percussion may readily appreciate it when it is reinforced by this simple method.

CONCLUSIONS

Impairment at one apex points to an abnormality needing investigation. There may be a deposit of tubercle, or an apical pleurisy of similar causation, or an apical collapse from peribronchial tubercle; there may, on the other hand, be a collapse of only simple causation, for description of which the reader is referred to p. 78.

Decision as to the nature and activity of the lesion which impairment has indicated must be made from further investigation; percussion alone can only answer for us certain questions, and these may be shortly stated as follows :—

1. Are the 'reflex bands' of impairment (see Fig. 3), indicative of an active parenchymatous inflammation, present or not?

2. Is there impairment at one apex? Decided by the softest percussion, with due regard to the fallacy of hyper-resonance on the opposite side. Reinforcement by respiratory percussion may be tried in cases of doubt.

3. How much impairment is there? Decided by increasing the weight of percussion, to see if it still persists.

4. Is it superficial (pleural), or deep, or both? Effect of comparing 'through' percussion with 'flipping' percussion.

5. Is there any deformity in size or shape of the lung apex? See Topographical Percussion, p. 62 *et seq.*

PALPATION

Inspection and palpation demand forced breathing for the comparison of movement on the two sides of the chest. Since such deep respirations disturb the lung for percussion, this part of the examination is best deferred till percussion is completed.

Asymmetry of movement. The investigation of respiratory movement is best performed by a combination of touch and vision. From the front the upward movement of the shoulders is best looked for either by watching the tips of the acromion processes from a distance, or with a hand laid flat on the upper part of each side of the chest with the tips of the fingers in the supraclavicular fossa. The forward expansion of the upper chest is best observed from the back with the patient seated and the hand on each side of the neck, the thumb behind, and the fingers down over the clavicle. Very slight differences can be detected by this method.

Three kinds of change are observed in cases of phthisis:—

Delay of movement on one side is the first change to be observed in apical phthisis, and may occur in quite early cases.

Limitation of expansion is a later sign. In cases of double apical disease this may be found over the more advanced lesion, and delayed movement on the side of fresh infiltration. The two signs thus furnish very important information as to the age and activity of disease on the two sides.

Equality of movement and expansion does not exclude pulmonary tubercle, since this is no uncommon find in

cases of hilus tuberculosis where disease is double from the start.

Interrupted or jerky movement may also be observed in phthisis. In addition, lagging of the base of the chest must be looked for.

Vocal vibration is of little real value in the detection of early phthisis; it follows the findings of auscultation, but is always a long way behind these.

Muscular Rigidity

It is common experience among those seeing much of tuberculosis that spasm of muscles over the area of disease is found in certain cases. This phenomenon has been studied by Pottenger since 1909, and he affirms that with rigidity of muscles there is always underlying disease and, vice versa, that he has never seen disease without some spasm of the muscles. This spasm is said to vary in position with the lesion: thus if this is in front, the sterno-mastoid, scaleni, pectorals, and intercostals are affected; if behind, the trapezius, levator anguli scapulæ, and rhomboidei. The affected muscle is firmer to the touch, and suggests hypertrophy, and for this reason it is important to inquire whether the patient is right- or left-handed. At a later stage and with chronic disease degeneration of the muscles, with wasting of the skin and subcutaneous tissue, is described.

While admitting the occurrence of spasm in certain cases, the writer has not been able to confirm the claim that rigidity is present in all. The method has not proved, in his hands, of any value in the diagnosis of pulmonary tubercle.

AUSCULTATION

Percussion and auscultation cling closely together in the detection of pulmonary tuberculosis—are, indeed,

the alpha and the omega of physical diagnosis. In the writer's experience, more than a provisional diagnosis is seldom justified from signs alone, unless some abnormality is discovered both to percussing finger and stethoscope. Signs which do not give evidence in both these fields to trained observation must generally be suspect. This is perhaps especially the case with auscultatory signs—these urgently demand the evidences of percussion for their confirmation. Indeed the rôle of these two methods must always be to a large extent complementary, and neither is replaceable by the other to any notable degree. The man who places reliance on either of them alone will certainly be badly 'caught out' before the game has progressed very far. "Many physicians," remarks Fishberg, "even such as devote all or most of their time to the practice of pulmonary diseases, rely solely on auscultation for the diagnosis of tuberculosis. There is no doubt in my mind that this is one of the reasons why incipient cases are so rarely recognised."

The difficulty in the use of the stethoscope is not a mechanical one as is that of percussion. It depends rather on the training of the ear in the elimination of unimportant noises, and in the recognition of abnormal sounds and their just interpretation. Most important for this purpose is the adoption of an enlightened routine of examination, for in auscultation we are investigating not one physical sign as in percussion, but several different points which should be clearly separated. Three main divisions—breath sounds, adventitious sounds, voice sounds—are readily made, and these must again be subdivided if the ear is not to be confused by trying to follow more than one point at a time.

The routine of examination. The usual plan of considering the breath sounds, which represent the earliest changes, before the adventitious sounds, which

are generally a later sign, will here be reversed for an important reason. In diagnosis it is always quickest and easiest to work by a process of exclusion, and the more certain and unequivocal signs should be ruled out before labour is expended on evidence which is more difficult to explain and often less trustworthy. So, in practice, if definite crepitations are present at an apex the condition of the breath sounds is, so far as diagnosis is concerned, of but secondary importance, and it is only where adventitious sounds fail that the difficult and laborious task of analysing the breath sounds becomes important and necessary.

A difficulty often encountered in auscultation is the ignorance of the patient on the subject of breathing. It is best to begin by comparing quiet natural breathing on the two sides of the chest, noting the quality and loudness of the breath sounds and the presence or not of adventitious sounds. Then the patient should be shown by example how to breathe so as to draw a fuller and more rapid stream of air in and out of the lungs. The tendency will be to arch the chest, raise the shoulders, and cease to expire. Instead of this an easy pose must be substituted with the shoulders forward and the chest flat, and attention must be directed rather to expiration than to inspiration. The mouth is best kept open if noisy breathing can be prevented. As a last resort a good air entry can generally be ensured by holding down the arm in front or by pressing on the shoulder behind. If these measures do not suffice, a good cough is nearly always followed by a deep and well-drawn breath.

ADVENTITIOUS SOUNDS

Almost any variety of added sound may be heard in phthisis according to the stage of disease present, and their significance from the point of view of diagnosis lies less in their character than in their localisation and persistence.

A common error is the belief that small or medium râles heard at one or both apices suffice for the diagnosis of phthisis. In practice this sign is frequently found in catarrh of all varieties of causation, and unless the râles are consonating, or there is an accompanying loss of percussion resonance, there is no justification for any diagnosis beyond that of catarrh. Such cases need re-investigation; for further particulars of them the reader is referred to the subject of apical catarrh, discussed on pp. 80 and 81.

In diagnosis, as already hinted, one passes always from the easier to the more difficult, and the order of procedure will be somewhat as follows: first it will be noted whether adventitious sounds are present during quiet breathing: if this is so, and especially if they accompany both inspiration and expiration, the case is no longer early. If they are absent, deeper breathing will be tried and their presence or absence noted. Finally, cough or, better, two or three coughs at the end of expiration, will be tried, and the inspiration following carefully investigated.

Especially should this manœuvre be tested over the apices in front, both above and below the clavicle, and behind over that part of the supraspinous region described by St. Chauvet as the "alarm area." This spot lies midway on a line drawn from the space between the seventh cervical and first dorsal spinous processes to the tubercle found on the spine of the scapula about the junction of its inner and middle thirds. Emile Sergent noted the first physical signs at this spot in 68 per cent. of cases, and the writer can confirm the value of fixing attention on this point.

Since the post-mortem demonstration by Kingston Fowler in 1888 of the 'line of march' of tubercle from apex of upper lobe to apex of lower lobe, followed by involvement of the opposite side, a very general and

sincere clinical effort has been made to utilise these 'seats of election' for the diagnosis of tubercular processes. The partiality of the tubercle bacillus for the top of the lung is, of course, a point of decided assistance is gauging the nature of an inflammatory lesion. "Given a chronic pneumonic process limited to the apex of the lung, or preponderating there," remarks Turban, "we may diagnose it as tubercular with the same degree of probability as we can attain in most internal diseases." But it is the involvement of the lower apex at a joint opposite the fifth dorsal spine which Fowler has claimed as so valuable an aid to diagnosis. "The infiltration of the lower lobe at this site," he remarks, "in the early stages of pulmonary tuberculosis of the chronic and fibroid varieties, is one of the most constant features of the pathological anatomy of the disease, and its recognition is a point of the greatest clinical importance, as the existence of a lesion in the lower lobe at this point coincident with physical signs at the apex . . . is almost positive proof of the presence of tubercular disease of the lung." In the writer's experience, nevertheless, this expected aid is but rarely forthcoming in practice; but rarely does the lower apex contain a focus so isolated as to afford assistance in diagnosis. Practically always, where this area shows evidence of disease, stethoscopic signs can be traced without break, or notable change of character, from the apex down to it. As for percussion impairment at this point, the writer has already given warning (p. 35) of the very fallacious simulation of disease presented by the lower of the 'reflex bands' of dulness.

It is true that occasionally an exacerbation in phthisis will concentrate on the apex of the lower lobe, but in such case the diagnosis will generally have been made long since. In rare cases, also, the lower apex in place

of the upper may be first involved on the second side attacked. But as a rule, knowledge of the 'seats of election' in tubercle helps us only so far as the upper 'seat' is concerned—so far, that is, as the predilection of tubercle for the top of the lung is able to carry us in diagnosis.

Should definite stethoscopic signs fail to be detected at a first examination, it is sometimes worth while examining again after a night's rest in the supine position: or potassium iodide may be given for a few days after the method of Sticker. If no adventitious signs can then be obtained, this, the most certain factor in auscultation, fails, and an exhaustive investigation of the breath sounds must follow. It may be remarked here that the breath sounds are not rarely normal in cases where adventitious sounds are already present. It must not be supposed that râles necessarily imply an open lesion: those due to exudation round grey tubercles represent quite an early stage of tubercular infiltration.

Spurious ràles. Very difficult at times is the exclusion of certain adventitious sounds which may be heard in healthy chests. The hairy chest and rough skin are too obvious to need more than mention. Tissue sounds brought out by pressure of the stethoscope may give rise to difficulty in certain subjects. Other spurious sounds are clicks heard above the clavicle due to swallowing, especially after cough, or head movement; creaks mainly heard in the interscapular and scapular regions, and probably fascial in origin; muscular sounds which are dull, rumbling, and rhythmic in character; collapse râles, which are very apt to deceive. Cabot found these last in 61 per cent. of normal chests, mainly in the infra-axillary regions and bases behind, but they may also be heard at an apex, and are common at the inner end of the clavicle and also over the spinous processes behind. They occur at the end of inspiration, have a dry and crackling quality which is generally sufficient to reveal

their nature, and tend to disappear after a few breaths, though this does not always happen. In a few healthy chests also the writer has noted dry crackles at both apices persisting for years without any other signs or symptoms pointing to disease, and has failed to discover to what these sounds were attributable unless atelectatic in origin.

In all the conditions mentioned above either the nature of the sound will serve for its identification, or its mode of production is obvious, or failing this, its importance must be determined by the careful exclusion of all other signs of disease. For further conditions likely to occasion difficulty in the interpretation of adventitious sounds in the chest, attention is drawn to examples of difficult diagnosis, especially catarrh and mitral stenosis, on pp. 80 to 83.

Râles in Phthisis

Great variety in the character of adventitious sounds in phthisis exists according to the manner and place of their formation, and we must be familiar with the fine inspiratory, non-consonating râle of passive exudation, the consonating râle of inflammatory consolidation, the click or grunt of softening caseous material, the localised coarse râle of peri-bronchial tubercle; and to these must be added the fine friction sound of apical pleurisy. For our present purpose, namely diagnosis, any adventitious sound may suffice to confirm the other findings. Especially characteristic in early stages are a few, perhaps three or four, sticky crackles at the end of inspiration. These may be only present after cough and with deep breathing; if present in large numbers and during quiet breathing the case can no longer be called early. At a still later stage they become moist râles, have a consonating or resonant quality added to them, and are heard in expiration as well as inspiration. Whistling or snoring sounds are sometimes present, especially with

stationary or healing lesions, due, perhaps, to compression of bronchioles by the fibrous tissue of repair. The essential point about these adventitious sounds, and indeed of all the signs in phthisis, is their persistent localisation; this is of especial value when only coarse râles are audible over the suspected area. If râles are widespread the general condition of the patient may be too good to admit of their tuberculous character. In such cases the grafting of a bronchitis onto a tuberculous process may sometimes supply the explanation. The higher up in the chest the signs, the more likely tuberculous; but basal crepitations may represent a hilus tuberculosis first reaching the surface in this area (p. 95).

Fine moist friction at the apex is sometimes impossible to separate from intrapulmonary sounds, and this is of less importance since its significance tells in the same direction. As a rule these friction sounds are heard not only at the end of inspiration, but also persist onwards into expiration; they are also apt to be heard over a larger area than would be râles corresponding to the stage of disease which the patient appears to have reached. Adventitious sounds can never be excluded till cough has been used to bring them out (see p. 49); the effect of cough also on sounds already present must be tested, since râles of merely bronchial causation can generally be removed or lessened by this means.

It has been noted by writers that broncho-pneumonic tubercle may have obviously reached an advanced stage without the appearance of adventitious sounds over the chest. Thus Isambard Owen remarked, "Tuberculous broncho-pneumonia is capable of advancing slowly without giving rise to any moist sounds at all." But the explanation of such cases must certainly be that the moist sounds naturally anticipated were out of reach of the stethoscope, the process being a central or hilus

tuberculosis of broncho-pneumonic type (p. 93). Whenever or wherever the surface is reached, the usual broncho-pneumonic signs appear as evidence of the process which has been proceeding unheard in the depths of the lung.

Recapitulation. To recapitulate the important points to which attention must be directed in an investigation of adventitious sounds :—

1. Examine during quiet breathing and then forced breathing, but never omit to test the effect of cough in bringing out râles where absent or in dispersing those already present. This test must be especially applied above and below the clavicle in front, and behind over the "alarm area" noted on p. 49.

2. The significance of adventitious sounds in phthisis depends less on their character than on their persistent localisation to a particular area of the chest, and on their predilection for the apex of the lung. Isolated involvement of the apex of the lower lobe is a valuable confirmatory sign if found, but it is but rarely present.

3. Remember that non-consonating râles at one or both apices only stand for catarrh, and are, by themselves, no justification for a diagnosis of phthisis.

BREATH SOUNDS

The breath sounds become of vital importance in cases where adventitious sounds cannot be obtained, for where these are present the breath sounds assume quite a minor rôle in diagnosis. Their value depends largely on the amount of training of the investigator, for the slight early changes debated by experts are readily overlooked, or discovered when they are not present, or, when present, are misinterpreted.

The examination of breath sounds has been greatly advanced by Grancher's discovery of "**single-phase**

auscultation." By this method inspiration and expiration are separately compared on the two sides of the chest, and especial attention is paid to inspiration, for it is now admitted that the earliest auscultatory signs of tubercular infiltration are found in this phase of the respiratory cycle. Attention is concentrated mainly on the apices of the lungs front and back, and especially on the subclavicular fossa; the head is directed straight forward, inspiration is noted on one side and, during the following expiration and pause, the chest-piece of the stethoscope is rapidly transferred to the opposite side to catch the next inspiration. In this way the very slightest differences are perceptible, and after inspiration has been investigated the same may be done for expiration or for the whole cycle at once.

Right-apex Phenomena

Reliance on the character of the breath sounds presumes a familiarity with certain anomalies of the normal chest, and especially important in this respect are the well-recognised differences between right and left apex. It is not sufficient to say that the breath sounds are of a more blowing character at the right apex, as is generally done, but a word must be said separately of both inspiration and expiration.

Inspiration shows less difference than does expiration at the two apices, and they may be strictly equal in this phase. More commonly inspiration is higher pitched, harsher, and therewith somewhat louder at the right apex. These changes are generally more noticeable in front; behind, more commonly, inspiration as well as expiration may in thin people have a somewhat blowing quality. Rarely, inspiration is higher pitched at the left apex.

None of these changes, except the blowing quality sometimes present, is suggestive of the alterations which occur in disease. Harsh breathing may suggest compensatory overaction but nothing more; higher pitch of

breath sounds is of no reliable significance and is found in both health and disease. A further peculiarity of inspiration often met in healthy chests is interrupted and broken inspiration due to cardiac excitement, or the effect on the neuro-muscular mechanism of nervousness or cold.

Expiration. The peculiarity of this phase at the right apex is more marked than is that of inspiration. Its main distinction is that it is louder than on the left side, and as a consequence of this is heard over a longer time, or 'prolonged.' In addition, it may be harsher and, in some cases, the tubular quality of both inspiration and expiration comes out so strongly as to earn the designation of broncho-vesicular breathing. This is especially common in the young and in adults with very thin chest walls. All these right-apex peculiarities appear to depend on the difference in size and direction of the right bronchus, and on the close relation of the trachea to the apex of the right lung. They are especially exemplified if the stethoscope is applied between the two heads of the sterno-mastoid muscle, or under the head of the clavicle, where the proximity of the trachea overcomes the vesicular murmur on both sides, but more strikingly on the right. Auscultation is useless at these points except for râles.

The differences above described are not confined to the apex but descend from this over a varying amount of the chest wall, sometimes extending over the upper half of the lung. They are especially marked in mouth-breathers and those with thin chest walls. Cabot has also pointed out that the breath sounds are commonly louder and harsher at the left base behind than at the right; he found the change in 67 per cent. of patients examined for it. The writer can confirm this observation, and would add to it that in most cases, also, inspiration here is higher pitched.

Breath Sounds in Phthisis

Just as when considering adventitious sounds, so with the breath sounds it is natural for diagnostic purposes

to pass from easy to more difficult. So we will take the more advanced changes first and pass from these to the earlier and more debatable.

(*a*) **Broncho-vesicular breath sounds** depend on an abnormal conduction of sound from the large tubes to the surface. This will depend for its degree on the amount of tubercular consolidation between these points, being greatest where disease covers the whole depth of the lung. There must be continuity of consolidated points to cause bronchial or tubular breathing—consolidation may be superficial, or only deep, and thus affect the voice but not the breath-sounds. Deep consolidation may give distant tubular breathing; interrupted or partial consolidation, a broncho-vesicular type of breathing. It has been estimated that half an inch of clear lung will prevent the transmission of tubular breath sounds to the surface. It is seldom that tubercular consolidation is so dense that actual bronchial breathing such as occurs in pneumonia is present, but all grades between this and the normal may be experienced, and the breathing is always comparatively low-pitched. Prolonged expiration is part and parcel of this type of breath sound, since the better this phase is conducted the longer it will appear to last.

Isambard Owen gives the following useful warning in the interpretation of blowing breath sounds. "If the expiratory sound, having the tubular or harsh character, is found to proceed with uniform pitch and intensity through the whole expiratory act, the breathing is truly tubular, and is evidence of consolidation. If it does not satisfy this criterion, if it varies in tone, or 'tails off' towards the end, it only indicates some trifling bronchial change. Mere prolongation of the expiratory sound, without the tubular or harsh character being manifest, does not constitute evidence of consolidation at all; the expiratory sound is equally prolonged

in some forms of false tubular breathing, in puerile breathing, and in the clear 'blowing breathing' which is so often met with over healthy, or merely emphysematous, apices, and which is probably of bronchial origin also."

In deciding on the presence of broncho-vesicular breathing attention must be directed to the normal apical differences, and slight grades are of far more significance at the left than at the right apex. In all cases where this type of breathing is present in phthisis some impairment is also present to skilled gentle percussion.

(*b*) **Feeble breath sounds** constitute, in the writer's experience, a valuable sign in phthisis if localised, persistent, and unremoved by deep breathing or cough, but they do not represent as a rule the very earliest change. The quality of the feeble breath sounds may be vesicular or granular, and they may be somewhat blowing; they are practically always accompanied by some change of percussion resonance to skilled examination. Not infrequently, also, an early crackle can be detected in these cases at the end of inspiration after cough. It must be noted that weak breath sounds may be found over healed tubercle as well as in early disease accompanied by symptoms.

(*c*) **Interrupted, wavy, or cogwheel inspiration,** "respiration saccadée" of the French, is an early but uncommon and highly unreliable sign. Some of the conditions which may cause it in the healthy are mentioned on p. 56; it is also common with pleural adhesions or with painful breathing, and may occur with bronchial catarrh; under these conditions it is generally heard over a large area of the chest, but for the diagnosis of phthisis it must be strictly localised. If it occurs only at an apex, on quiet breathing, persisting over several examinations, and other causes already mentioned can

be excluded, it is worthy of attention, but by itself does not suffice for even a provisional diagnosis of phthisis.

(*d*) **Granular and rough inspiration,** "respiration rude" of Grancher, consists of an impurity of the vesicular murmur attributed by this author to slight narrowing or irregularity of the bronchiolar passages. Turban suggests as a further factor that "small airless nodules are scattered through the air-containing tissue, and the air rushes in jerks into alveoli still patent but obstructed by the proximity of these nodules." Sahli attributed granular breathing to the fusion of vesicular breath sounds with adventitious sounds due to secretion in the bronchioles. "When these added sounds can be distinctly differentiated as such from the breath sounds we speak of râles; if not they generally give an impure rough character to the vesicular breathing." The writer can confirm this impression, and would add his conviction that in many cases granular inspiration is caused by crepitations just too deep in the lung to assail the ear as such. In cases of hilus tuberculosis where deep disease is reaching the surface, such granular breathing may at times be audible over quite a large surface; at a later stage, or as a result of strong breathing, the granular sound is found to resolve itself further into a distinct series of inspiratory crepitations.

Whatever its explanation, granular inspiration represents the earliest auscultatory sign of phthisis, and passes over into interrupted inspiration or râles at a later stage. It must be especially looked for in the supra-clavicular and supraspinous regions, and also below the inner end of the clavicle; like other signs of tubercular infiltration, to be of value it must be localised and persistent. It may be caused by catarrhal conditions of all sorts, and has been noted in enteric fever, heart disease, pleural effusion, and other maladies; its service is rather to direct suspicion to a patient's

lung than to provide any more definite element in diagnosis.

Harsh breathing is not a sign of phthisis, but occurs where there is compensatory over-activity in the healthier lung, or over a healed focus. It is normally heard, as puerile breathing, over the lungs of children.

It must be noted with regard to all these breath-sound changes that none of them are in themselves indicative of tubercular infiltration, but all may be open to other interpretation. Thus a simple bronchial catarrh with a modicum of collapse, a not infrequent condition, may explain any one of them, and for this reason it is wise to defer an opinion till a second or even a third examination, unless other confirmatory signs are present. In forming a decision on the significance of breath-sound changes, two points come out for special investigation: (1) Are they strictly localised to a small area of lung tissue? (2) Are they present at the same spot on more than one examination? If they do not fulfil these two requirements their significance vanishes. Thus it is rather in the localisation than in the character of the sign that its value lies, and it may be said that any anomalous form of respiration fixed and confined to the summit of the lung suffices for a provisional diagnosis of phthisis.

Recapitulation. The important points in examination of the breath sounds can be conveniently recapitulated as follows :—

1. Examine inspiration and expiration separately, directing especial attention to the former.

2. Having discovered an abnormality, consider the following points :

(*a*) Can it be only a physiological difference between the two sides (pp. 55 and 56)?

(*b*) Is it heard over a wide area or strictly localised?

(*c*) Is its localisation related to an area where tubercle commonly appears?

(*d*) Is its localisation persistent: does it remain on more than one examination?

(*e*) Is it supported by evidence from other sources, such as impairment to gentle percussion?

Voice Sounds

Vocal resonance, and especially the transmission of the whispered voice sounds, may be sometimes of use, at least in the confirmation of signs derived from other methods of examination. In the healthy chest the whispered voice is only audible over the upper third, and that more strongly on the right side; over the lower parts of the chest it is hardly audible, or quite inaudible. Any increase implies increased sound conduction, and points to consolidation or congestion of the lung parenchyma.

As a rule, evidences derived from examination of breath sounds and voice sounds cling together and supplement one another—tubular breathing is associated with a corresponding increase of vocal resonance; but under certain conditions this is not so. A deposit of tubercle may not come near enough to the surface to affect the breath sounds and may yet give evidence to vocal resonance. On the other hand, it takes more consolidation to bring out a bronchophony than it does to produce blowing breath sounds; hence harsh breathing without change in vocal resonance implies less disease than do the same breath sounds with bronchophony. Vocal resonance is, in the writer's experience, but seldom of real value in the diagnosis of early apical tuberculosis.

What was said about breath sounds at the right apex applies equally to vocal resonance; in normal chests there is a greater intensity here than at the left. If vocal resonance is equal on the two sides and loud, there

is probably some disease at the left apex, and the louder it is the greater the probability. If, again, it is equal but diminished, some cause of diminution at the right apex is implied—a thickened pleura, emphysema, and the like.

TOPOGRAPHICAL PERCUSSION

The careful mapping out of the apex of the lung is a method which enormously repays the small amount of time and trouble required, and should never be neglected in a case where the diagnosis of phthisis is in real doubt. It is, moreover, by no means difficult of accomplishment, once the details have been mastered. "Indeed," as Fishberg remarks, "it is much easier to learn than comparative percussion, and requires no musical ear." Many methods have been described, and it is important that those which supply the most valuable evidence should be selected.

History. The upper boundary of resonance above the clavicle appears to have been first described by Heyer in 1863; this was again brought to notice in 1880 by Weil, who at the same time described, but inaccurately, the upper boundary behind.

Krönig, using light percussion, again worked out these limits in 1889, altering especially the posterior line, though recognising that its new position did not conform with the anatomical boundary of the lung apex. Later he appears to have attempted to bring anatomy into line with his percussion areas, affirming that the lung apex lay farther from the vertebræ than had been previously held. After much labour on his inner boundary he was led by chance to map out an outer boundary of the resonant space, and carried this over the shoulder front and back. There thus arose an anterior and a posterior area of apical resonance united by a narrower 'isthmus'

(see Figs. 8 and 9, pp. 67 and 68), and their determination and comparison in phthisis form the test associated with his name.

That they represent the anatomical apex of the lung, however, was an assumption which was easily disproved, apart from the evidence of anatomical preparations. An orthodiagram of the lungs in their relation to the chest clearly shows the apex in front to lie behind

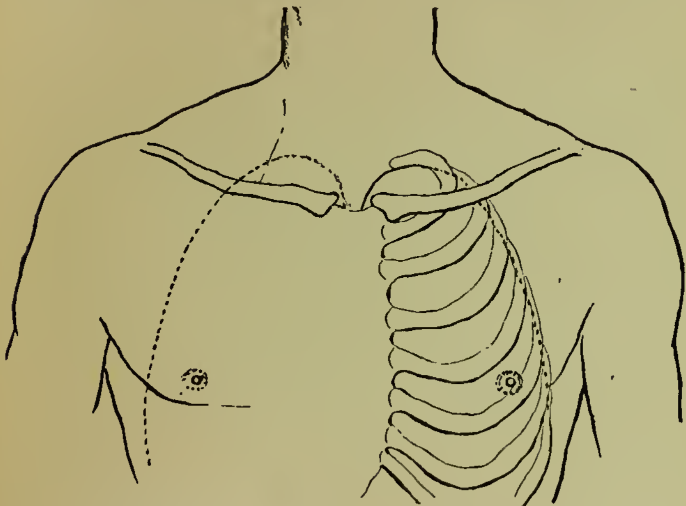


FIG. 6.—The true position of the lung apex in front.

the heads of the sterno-mastoid muscle above the inner end of the clavicle (see Fig. 6), and this can be visually verified by watching its protrusion at this point in thin subjects during cough or, still better, in wasted infants during crying. In the same way at the back the apex is found to reach the first dorsal vertebra at the dip between its spinous process and the origin of the first rib (Fig. 7). The true apex is, in short, close in to the neck, and thus bears no direct relationship with Krönigs' area

of resonance. This was first pointed out by Goldscheider in 1907, and he recommended mapping out by percussion the true lung apex, in front between the heads of the sterno-mastoid muscle, and behind at the spot already indicated. Von Ziemssen had already described this posterior apex between the first rib and first dorsal vertebra.

The two methods. We are thus presented with two

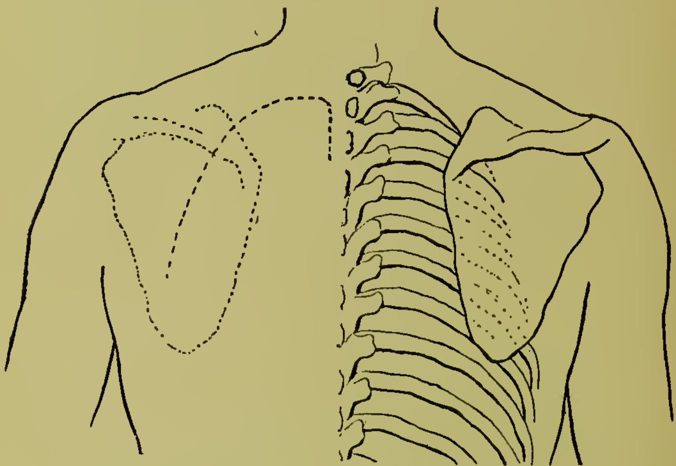


FIG. 7.—The true position of the lung apex behind.

methods of topographical percussion—one the actual delimitation of the apex front and back, **Goldscheider's method**; the other the measurement of an artificial band formed by the projection, tangentially, of resonance from the outer surface of the apex in various directions to the surface, **Krönig's method.** The areas concerned with both these methods have a clinical actuality; Weinberger found the boundaries of both correct to light percussion, and the writer can concur with this. As a matter of clinical experience, Krönig's sign is of considerable utility in the diagnosis of early phthisis,

and equally or more so of central lung, or hilus tuberculosis (p. 95). By its means Oestreich was able to detect foci of cherry size in experiments on post-mortem material, and to find a shrinkage of the apex in very early stages of phthisis; clinicians have mostly endorsed this opinion. The projected resonance supplies useful magnification of the lung beneath, so that very slight retractions of the apex are recognisable by this method.

The application, on the other hand, of Goldscheider's method is, in actual practice, much more difficult. The resonance between the sterno-mastoid heads is very hard to map out, as the apex reaches little more than a finger's-breadth above the clavicle: Stuart Dickey says 2·2 cm., or nearly an inch; Weinberger speaks of 4 cm. (see Fig. 6). Moreover, when its outline has been determined there is here no convenient point from which an accurate measurement can be taken, for the clavicle presents only a rounded contour, and its upper surface at the inner end is difficult to reach. Behind, the true apex of the lung is separated from the surface by rib and transverse process (Fig. 7), and by a thick pad of muscle lying between these and the vertebral spine. It is on this account that resonance is somewhat masked at this point, and it is not till we get farther out into Krönig's area that lung resonance becomes clear. Goldscheider's percussion, as carried out by himself, is an extremely difficult and laborious undertaking. In addition to marking the upper limit, he sets out in front to percuss over the first rib above the clavicle, the shoulders for this purpose being raised and loosened so that the pleximeter finger can dip down to the rib beneath. Behind he removes the scapula as far as may be from the area of research by sitting the patient with the arms thrown forward over a vacant stool.

Taking the evidence discussed above into consideration, and as a result of practical experience with both

methods, the writer would recommend reliance on the following points :—

Goldscheider's method

Mark the upper boundary of the apex behind on each side, percussing from below upwards, and compare the height of the apices on the two sides (see Fig. 13, p. 74). The lung should reach to the tip of the spinous process of the first dorsal vertebra, and the investigation of this point is easy and affords useful information. In front compare the resonance on the two sides between the heads of the sterno-mastoid muscle, but make no attempt at measurements.

It may here be remarked that the opportunity for percussion over the lung apex in front depends on the insertion of the sterno-mastoid muscle in this region. The space between the two heads of the muscle varies with the width between their attachments and the varying prominence and importance of sternal or clavicular portions. Occasionally it is possible to percuss straight backwards through the outer head on to the lung apex, but often the plane of the muscle directs percussion markedly inwards so that the lung note is vitiated by resonance from the neighbouring trachea.

This does not interfere with the comparison of the two sides so much as might be expected. The head must be held towards the middle line and tilted somewhat forward, since muscular tension on one or both sides may greatly alter the percussion resonance.

Krönig's method

Krönig's area is better seen than described, and the reader is referred for this purpose to the accompanying diagrams (Figs. 8 and 9, pp. 67 and 68). The head must be directed straight forward throughout, the anterior

muscles being slack; the area must be mapped out carefully with very gentle percussion, the edge being marked with a skin pencil and carefully verified after it is marked. Contrary to the opinion of some, it makes no difference, in the writer's experience, whether percussion is made from resonant to dull, or vice versa, or whether indeed both methods are employed together. It must, however, be remembered that the pleximeter

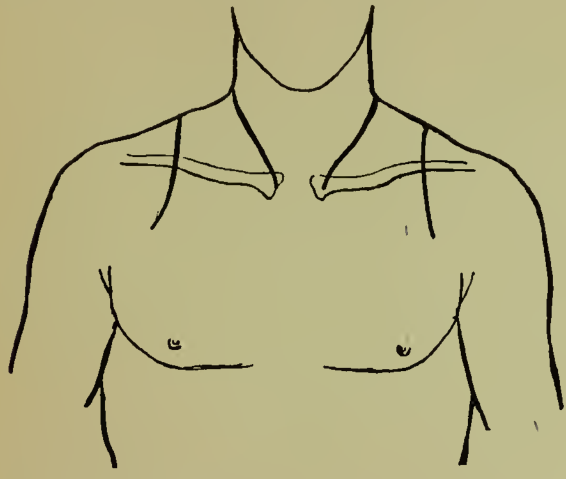


FIG. 8.—Krönig's areas of apical resonance: front.

finger has an appreciable width and the whole breadth of the finger must cover resonance or dulness, according to the direction in which one is moving, before the edge is pencilled. Moreover, it is best to use the tip of the finger only, since if the whole length is laid upon the skin it may not lie parallel with the edge of the lung, and one end may overlap resonance and the other end dulness.

If these points are carefully observed, it is claimed that an accuracy up to about $\frac{1}{4}$ cm. of error in the healthy and about 1 cm. or less of error in cases of disease is

possible of attainment. It must be noted whether the edge is sharp and easy to map out, since blurring of the outline, especially on the inner side, is one of the earliest signs of disease (see Fig. 10, p. 69). Where the edge is not sharply defined an attempt may be made to map out a band of 'relative' resonance outside that of clearer resonance within. After each side has been mapped out, measure with a tape the 'isthmus' and, if desired, the bases at the clavicle in front and at the

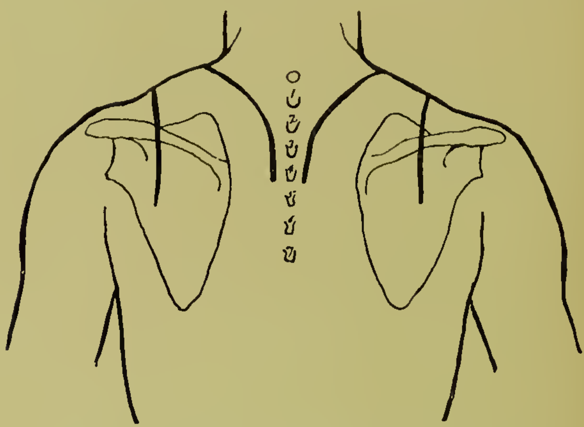


FIG. 9.—Krönig's areas of apical resonance: back.

level of the first dorsal spine behind, dividing the area into 'absolute' and 'relative' in cases where this is necessary. For practical purposes a simple determination of the width of the isthmus is all that is required, and for this undertaking 'relative' impairments may safely be neglected. The isthmus in health is generally 5 cm. (or 2 inches) across, and should not fall below 4 cm. In persons of sedentary occupation—clerks, tailors, and the like—and also in those of small stature and poor development, the apical resonance may normally reach only 4 cm. in extent. Apices of $3\frac{1}{2}$ cm.

or below are, in the writer's experience, decidedly pathological. Having taken these measurements, compare the percussion resonance on the two sides, and this may be done with advantage, as R. W. Philip recommended, in finger-breadths, 1, 2, and 3, above the clavicle. Comparison of the two apices by percussion

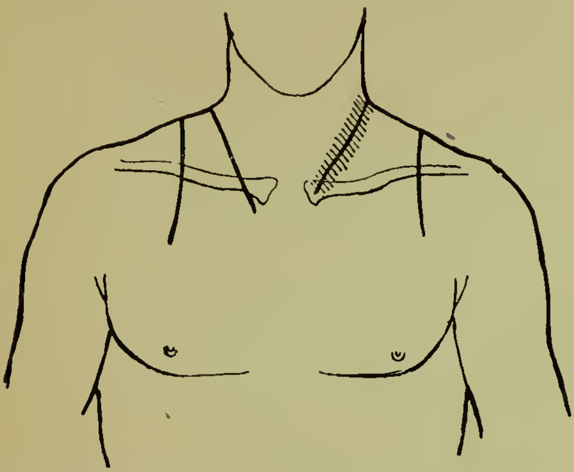


Fig. 10.—Krönig's areas in Apical Phthisis. Showing retraction at the right apex and blurring of the inner boundary at the left apex, a condition characteristic of this disease.

is rendered much more easy and certain by the careful mapping out of these areas of resonance beforehand.

Changes in pulmonary tuberculosis. For many years past the writer has been accustomed to mark out Krönig's isthmus as a routine practice in all cases of lung disease, and has found it of the very highest utility. The earliest changes, in cases of tubercular infiltration, consist in a blurring of the outline of resonance (Fig. 10). This may occur on both outer and inner side, but commonly affects the latter most markedly at first. This blurring of the edge is attributed by Krönig himself to

a change of tension in the lung tissues at the margin of the affected area; he accepts the explanation of Birch-Hirschfeld that the earliest change is in the apical bronchus, the obstruction of its lumen with tubercular material leading to stasis and absorption of air in the parts beyond. This indistinct outline leads to difficulty in marking out the area of resonance, and soon a definite reduction of its surface appears and impairment over

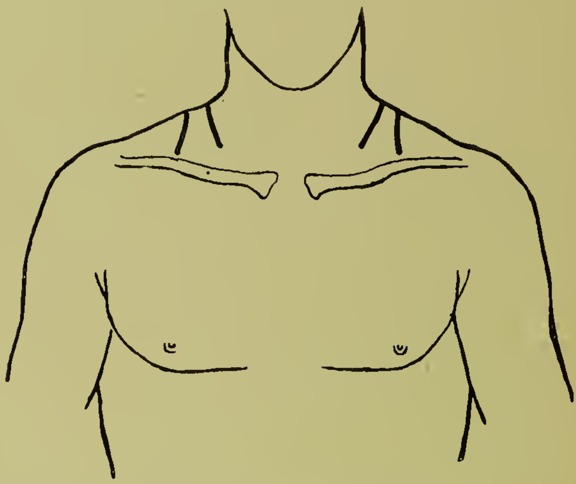


FIG. 11.—Krönig's areas in Hilus Tuberculosis, showing marked retraction at both apices.

it. These changes may precede auscultatory signs, and also symptoms such as cough and expectoration. They may greatly help to focus attention on an apex in a case of suspected disease. "When nothing else connected with the clinical history of the case," remarks Fishberg, "could verify the diagnosis, I have often been able to acquire a strong suspicion, or make a positive diagnosis by the aid of Krönig's method before auscultatory signs have given any indication of an apical lesion."

Topographical percussion is especially valuable in

detecting the presence of old and healed disease. It often gives the first sign, also, of disease in a second apex, where slight impairment is missed for want of a standard of comparison, and where ausoultatory signs are absent or doubtful. In addition it furnishes incontrovertible evidence of the presence of deep lung changes, whether active or arrested, in cases of 'central' disease, such as hilus tuberculosis (Fig. 11), before the process has yet reached at any point the surface of the chest. The physical examination of a difficult and doubtful case of chest disease is not complete without the comparison of Krönig's areas of resonance.

Conclusions. Topographical percussion carried out in the manner suggested above may supply us with the following information :—

1. The resonant areas are equal and of normal extent : evidence of healthy lungs (Figs. 8 and 9).

2. The areas are of normal measurement, but one is displaced in position : a condition described by Krönig under the name of "physiological heterotopia."

It was this condition which first led to the discovery of Krönig's outer boundary. In a case under his observation where the inner line was displaced, he was unable to discover any corroborative sign that this was due to disease. He therefore explored the outer limit of the resonant area, and found that this also was dislocated outwards, but the extent of the area of resonance equalled that on the sound side. In cases of retraction he found the area diminished as well as the inner line displaced.

3. There may be a blurring of one or other or both margins of the resonant area (Fig. 10, left apex) with or without some general loss of resonance : a condition suggestive of early phthisis. In this case bands of 'relative' resonance may sometimes be marked out and measured on either side of a central area of better percussion note.

4. A difference in the width of the isthmus on the two sides may be discovered. This may be due either to expansion of one side or retraction (see Fig. 10, right apex) of the other, or both conditions may be present; these points are decided by measurement.

(*a*) Unilateral expansion of Krönig's area may be due to compensatory emphysema. When emphysema is bilateral, as in chronic bronchitis, there may be slight widening of the isthmus, but more often it is rather below than above the normal (see p. 101, and also Table below).

(*b*) Unilateral retraction may be due to tubercular changes recent or remote, or to collapse either passing or more permanent, or to induration the result of collapse (pp. 78 and 79). Bilateral narrowing is characteristic of hilus tuberculosis (Fig. 11), but may also be brought about by fibrosis due to inhalation of dust.

Care must be taken that differences due to chest deformity, such as accompanies scoliosis, are not attributed to disease. It seems probable, also, that in some cases developmental deficiencies are responsible for asymmetry in the lung apex apart from disease in the lung.

The following Table gives, for purposes of reference and comparison, the measurement of Krönig's isthmus in a series of cases taken at random from the writer's case cabinet. It illustrates the changes which may be expected among these classes of patient.

Chronic Bronchitis.		Hilus Tuberculosis.		Apical Phthisis.	
Right.	*Left.*	*Right.*	*Left.*	*Right.*	*Left.*
4¾	4¾	2½	2½	5	3
4	4	3	2¾	3½	6
4½	4½	2½	2	2½	5½
3½	3½	2½	2½	2¾	4
5½	5½	3	3	4½	5
4¾	4¾	4	3	2½	4
4½	4½	2½	2½	6	3

Tidal Percussion

Tidal percussion discovers the vertical excursion of the lung in the complemental pleural space during inspiration and expiration.

At the **apex** the movement is best measured by marking the highest point of the apex, that is the inner

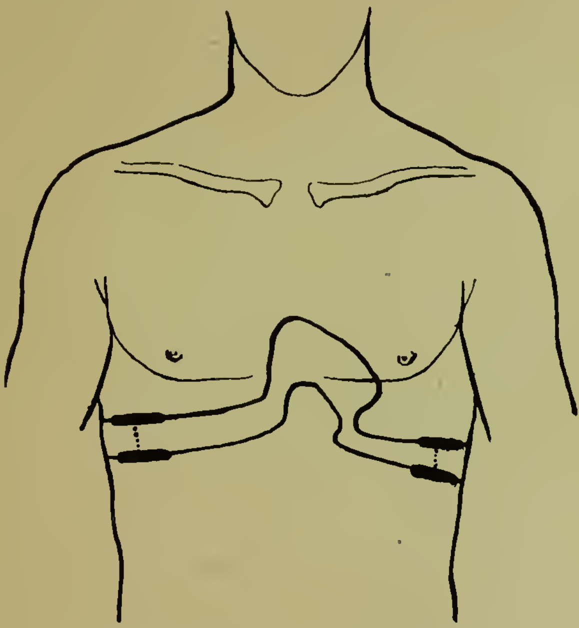


FIG. 12.—Tidal percussion : front. The thick lines represent the most convenient points of measurement.

boundary of Krönig's area (Fig. 8), during quiet breathing, and again during deep inspiration, and comparing the expansion with that on the opposite side.

The amount of this expansion varies in health from nothing at all to a couple of centimetres or so, according to the manner of breathing; the excursion is so small

and so difficult to determine with accuracy that little help can be derived, in the writer's opinion, from apical tidal percussion.

At the **base** of the lung expansion is notably greater, and furnishes information of some value. The excursion of the lung is indicated in Figs. 12 and 13; the writer finds that the most convenient points at which to take

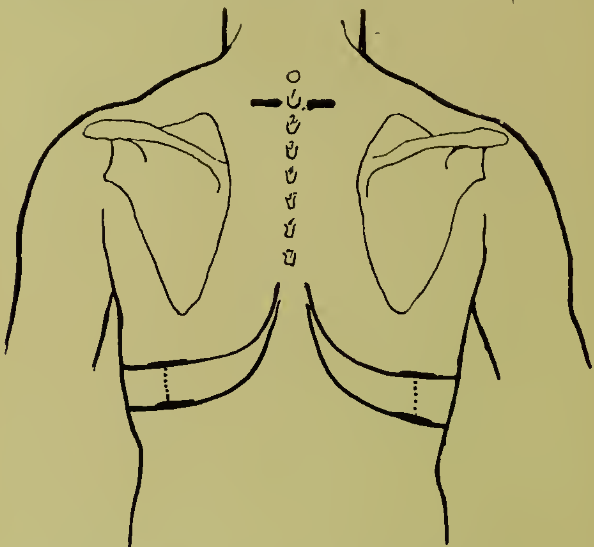


Fig. 13.—Tidal percussion: back. The thick lines represent the most convenient points of measurement. Above is shown the marking of the upper boundary of the apex by Goldscheider's method.

this measurement are the anterior axillary line and the centre of the base behind (see thick lines on these diagrams).

The edge of the lung is percussed out during quiet breathing, and marked with a skin pencil on both sides. A deep inspiration is then taken and held, and the edge again marked at the same points. Normally the lung descends quickly and smoothly into the pleural space,

and a vertical measure is obtained, varying, with the individual and with vigour of respiration, from $3\frac{1}{2}$ to $6\frac{1}{2}$ centimetres. The excursion is generally more in the anterior axillary line than behind, and is apt, in the writer's experience, to be somewhat more on the left than on the right side in health. Moreover, it will be noticed that the base of the left lung lies some centimetres lower than that of the right during quiet respiration. Allowance in amount of excursion must be made for emphysema, where the movement is minimal but equal, for advancing age, and for such conditions as chest deformity, pain in the side, ignorance how to breathe, and other conditions which may prevent full expansion on one or both sides.

In phthisis the excursion of the lung is often diminished over the affected side, even in early stages. In this respect the test falls into line with Williams' diaphragmatic phenomenon (p. 133), which exhibits but another aspect of the same defect. The failure of tidal movement may be due to loss of pulmonary elasticity from disease, to pleural adhesions, or to paralysis of diaphragmatic movement. In practice these various factors cannot be always separated or assessed. Certainly tidal movement may remain in spite of chronic lung infiltration of considerable amount, and the pneumothorax treatment of pulmonary tuberculosis has taught us that it may fail in cases where the whole pleural surface is free and unadherent. Where the limitation of movement is confined to one aspect, front or back, of the lung, which not infrequently occurs, its dependence on pleural adhesions may be confidently asserted. It is, in the writer's experience, particularly in cases of early 'central' or hilus tuberculosis that the sign may be of assistance, for it may present evidence of an abnormal condition at a time when but few signs of disease can be demonstrated at the surface of the

chest (see p. 103). Krönig has, moreover, pointed out its importance in helping to decide the tubercular nature or otherwise of cases of apical pulmonary fibrosis (see p. 79).

THE LARYNX

Laryngeal tuberculosis is commonly a somewhat late complication of phthisis, but occasionally the larynx is involved sufficiently early to make its investigation of assistance in diagnosis. Slight weakness or ready tiring of voice, thickness in the early morning, or a tickling or pricking sensation in the throat may call attention to this organ, but its routine examination is called for in cases of doubtful diagnosis apart from symptoms. The familiar anæmia of the larynx, or catarrh with hyperæmia, may be present in early stages, but neither is of help in diagnosis. The first signs of real diagnostic value appear as a rule in **the posterior commissure** as a greyish-pink or congested table-like elevation, often divided by a furrow into two halves, and this gives place later to a shallow ulcer.

Tuberculomata may also be found in the posterior commissure, and are distinguishable from granulations by their firm consistence.

Thickening or congestion of **the arytenoid region** occurs early; the aryepiglottic folds and epiglottis are affected later.

The vocal cord on one side may be early affected, and become red, thickened, and spindle-shaped, and later proceed to erosion or ulceration. From this may result a characteristic nibbled appearance, or a line of ulceration extending right along the cord. Thickening and infiltration of one of the false cords may occur early and partially hide the true cord beneath.

In the diagnosis of tuberculosis of the larynx it must be remembered that simple catarrh is common and

of no diagnostic significance. We require the presence of localised or one-sided changes, which may be either **infiltration, ulceration,** or **tumour formation.** Ulceration must be diagnosed from syphilitic changes. **Tubercular ulcers** tend to be multiple, to coalesce and spread superficially, and to show an irregular undermined edge and a dirty base; they are most common on the posterior wall, or the posterior third of the cords. They may show a focal reaction to an appropriate dose of tuberculin. **Syphilitic ulcers,** on the other hand, show a firm and deep infiltration, with a steep edge, and are surrounded by bright red mucous membrane; they are seldom found on the posterior wall. The effect on them of salvarsan or potassium iodide may be tried in cases of doubt. Tubercular tumours may be confused with fibroma, papilloma, or carcinoma.

DIFFERENTIAL DIAGNOSIS

No attempt will be made to portray the various diseases in which a diagnosis of phthisis has been or might be made, nor those for which phthisis is from time to time mistaken. They diminish in number with the increased skill and knowledge of the physician, and no more will be done here than to indicate shortly certain phases of disease which do really simulate tuberculosis of the lung, and also, conversely, certain conditions under which phthisis is apt to be masked by the symptoms and signs of other diseases. Apical collapse, whether with or without signs of catarrh, is a condition which may well tax the skill of the experienced physician, and several phases of its occurrence will find description here. Œdema of the lung occurring in mitral stenosis or with acute nephritis may cause difficulty, and bronchiectasis is an unfailing source of error both

among children and adults. On the other side of the picture we have tuberculosis masked by asthma, or complicating chronic bronchitis, and also basal phthisis.

The important subject of hilus tuberculosis in the adult will claim a separate chapter to itself.

Apical Pulmonary Collapse

Deficient expansion of the lung apex is a not uncommon phenomenon; simple collapse may be temporary, and is found, as was pointed out by W. R. Huggard of Davos and also by the writer, not infrequently in healthy people if percussion is made to precede palpation and auscultation. It clears up under deep breathing, with or without audible crackles, but is very apt to return at the same spot. In some cases its causation appears to be postural.

Collapse also attends bronchial catarrh, both of children and adults (see case on p. 80), and is very apt to occur in all conditions of mouth-breathing, especially adenoids in children and hypertrophic rhinitis in adults, and also, in the writer's experience, where inspiratory suction is diminished from such cause as atrophic rhinitis. Under these circumstances the collapse may remain permanent and the affected portion of lung undergo fibrosis (see case on p. 79). Such conditions were described by Krönig as mainly occurring at the right apex, and with this the writer agrees, though the left side is affected in some cases. Krönig explains the event as follows. He says the mouth-breathing leads to direct inhalation of cold and dust-laden air, and this especially into the right lung, whose suction power is greatest. By these means recurrent catarrhs are set up, with blocking of tubes and extending areas of collapse, these areas becoming indurated by chronic inflammation.

Those who have had the opportunity of examining the chests of large numbers of healthy people must be

struck by the frequency with which old apical collapse is found. It must always be a matter of conjecture how these cases have come about; the majority, doubtless, are of tubercular origin, but it seems certain that at any rate a proportion of them are of other causation. The signs are impairment to percussion in the supraclavicular and supraspinous fossæ, and sometimes below this, often limited behind in a sharp line at the interlobar septum; retraction of Krönig's resonance; and with these changes perhaps slight alteration of the breath sounds or some broncho-vesicular breathing. The differential diagnosis of simple collapse from tubercular conditions is made on the following points—

(*a*) A history of nasal obstruction and recurring catarrhs.

(*b*) The failure of all symptoms associated with tubercular disease.

(*c*) Normality of the opposite apex, and absence of all signs of tubercle elsewhere.

(*d*) Absence of pleural adhesions. This is determined by the fact that full respiration is obtained over the lung below, and also that the lung, each side, on deep inspiration fills the complemental pleural space at the base in a normal manner (see pp. 74 and 75, and Figs. 12 and 13).

Pulmonary Collapse and Fibrosis

A youth, aged 16½ years, gave a history of good health but of cough with some expectoration since seven years old, when an operation for adenoids and enlarged tonsils was performed. Mouth-breathing had continued up to two years previously, since when the nose had cleared, presumably with the growth and development which occurs at puberty.

The youth was well grown and well nourished, the weight was satisfactory, and he had gained 6 kilos. during the past year. The nasal respiration was poor, the nasal secretion excessive, the tonsils normal.

The chest showed impairment to percussion at the right apex, extending down to the second rib in front and to the interlobar septum behind, but with no impairment over the lower lobe or opposite apex. Movement was a trifle less on the right side. To auscultation there

were dry crackling râles at the end of inspiration and just after the beginning of expiration; these lessened somewhat after deep breathing. The breath sounds were somewhat blowing in quality. A few crackles were audible at the left apex also. Krönig's isthmus measured 3¼ cm. with a sharp margin on the right side, and 5 cm. on the left. At the base tidal movement was equal on both sides, 4½ cm. in the anterior axillary line and 3½ cm. behind.

The same signs were present three months later, and he had gained a further 2 kilos.

Acute Apical Catarrhs

A simple acute rhinitis or 'cold in the head' is, in the young, quite commonly accompanied by a mild bronchial catarrh. This may occur without any cough or other symptom, and is only revealed to auscultation of the chest. In these cases the signs are not infrequently confined to the interscapular regions or apices, and may, where their occurrence is unfamiliar, give rise to suspicion of more serious disease. At times, also, blocking of tubes may lead to temporary collapse in one or other lung, and bring the signs still nearer to simulation of phthisis. In deciding on the diagnosis in these cases it must be borne in mind how often tubercular disease begins as a series of 'colds,' and the suspicion must not be put aside too lightly. It must be remembered also that in double early phthisis, which these conditions simulate, it is often somewhat difficult for want of a normal standard to appreciate the presence of impairment to percussion. It is wiser, therefore, unless the physician is well skilled in chest work, to let the suspicion wait for time to remove it, and this will soon happen in the presence of simple catarrh alone.

Apical Bronchial Catarrh and Temporary Collapse

A youth, aged 16 years, had suffered with attacks of cough and nasal catarrh for the past four months. There was no former history of nasal obstruction or adenoid operation, but he sleeps with the mouth open and opens it on slight exertion.

The youth was well grown and of fair nutrition, the nose blocked with secretion, the pharynx red, and the cough largely pharyngeal. The

chest showed slight impairment at the right apex, extending to the interlobar septum behind, but with no impairment over the lower lobe or opposite apex. A few râles were audible front and back. Krönig's isthmus measured $3\frac{1}{2}$ cm. on the right and $4\frac{3}{4}$ cm. on the left side.
After three weeks' treatment he was seen again. There was still naso-pharyngeal catarrh, but the apical collapse had cleared and Krönig's areas were of normal and equal size. A few râles at the end of inspiration remained at both apices, and were not present elsewhere in the lungs.

In some cases, however, and that especially where the influenza bacillus or streptococcus are responsible, a more decided lung invasion occurs in the form of a localised broncho-pneumonia, and this may be for a time very difficult to distinguish from a similar lung condition produced by the tubercle bacillus. Pfeiffer's bacillus in particular may give rise to conditions which tend to simulate tubercle. A localised patch giving impairment to percussion and the intensely 'sticky' inspiratory crepitations characteristic of the condition will be found, generally at the base, but now and then at the apex. That this is, as a rule, only a localised bronchitis with congestion and collapse is demonstrated by the fact that the reflex bands (p. 34) indicative of parenchymatous involvement are generally absent; the vocal resonance is, also, often diminished rather than increased. In addition a true broncho-pneumonia caused by the influenza germs may also be met with in times of epidemic. These conditions differ from tubercle in the acuteness of onset with 'influenza' symptoms at a time when this disease is prevalent, in the more marked illness and prostration, with tremulous foul tongue and high fever, and in the subsequent rapid recovery.

Such cases of influenzal causation apart, the writer is of opinion that invasions by pyogenic organisms almost invariably fasten on tissues already diseased, whether a smouldering tuberculosis or a bronchiectasis (p. 83), even though the presence of such disease had

not been recognised before the onset of the acuter symptoms.

Turban, referring to "Apical pneumonias of unusual duration or incomplete resolution, whether due to diplococcus, influenza, or streptococcus infection," remarks: "If in such cases careful attention is paid to the history as well as to the physical signs, suspicion will often arise of a tubercular affection of longer standing, *e. g.* such factors as predisposition, or some old contraction may be discovered, when the case is evidently one of primary tuberculosis with a transient or lasting mixed infection."

Chronic Bronchitis with Collapse simulating Phthisis

Certain cases of chronic catarrh with scanty sputum show a marked tendency to an apical distribution and the occurrence of lung collapse, and this may give rise to signs whose shifting nature and subsequent course alone enables us to separate them from those of phthisis.

A woman, aged 41 years, suffered with pains in the chest when the weather was damp. She was pallid, somewhat anæmic, with a high pulse tension and chronic mastitis in the right breast. In October, 1909, the lungs showed impairment to percussion and fine crepitations at the right apex front and back, and a few of these latter at the left apex also. A month later all moist sounds had disappeared, but there was fleeting impairment at both apices, especially the right, and also at the scapular angle. A week after this the lungs were clear. The conjunctival tuberculin test was negative. Examined again in May, 1911, there were found a few râles at the apices but no impairment. In January, 1912, the chest was clear.

In some examples of this kind seen by the writer the apical signs have moved from side to side on different occasions when the chest was examined. In all such cases the pulse tension is a useful clinical guide, especially in women in whom some rise of blood pressure is nearly always found associated with chronic bronchitis.

Pulmonary Œdema in Mitral Stenosis and Nephritis

The rarity of tuberculosis as a complication of mitral

disease, and especially of mitral stenosis, has been, perhaps, rather unduly insisted on; it is a combination which is met with occasionally, at any rate, where cases of chest disease collect together. The condition to which attention is now directed is œdema associated with mitral stenosis occurring in other parts of the lung than the base. With this event impairment to percussion and crepitations will be found, the question of phthisis raised, and a differential diagnosis often very difficult to make. The writer has seen such œdema affecting the lung apex demonstrated on the post-mortem table where phthisis had been diagnosed during life. Tuberculosis is further simulated by the wasting, pallor, cough, and hæmoptysis which are all equally characteristic of mitral stenosis. The results of physical examination in such cases must be supported by repeated sputum tests, by X-ray examination, and especially by the effect of cardiac treatment on the lung signs. Pulmonary œdema occurring with pleural effusion has been already referred to on p. 14.

That acute nephritis may be accompanied by a localised pulmonary œdema the following case affords illustration—

A boy, aged 11 years, was admitted to hospital with acute nephritis. There was marked œdema of legs and feet, and the eyelids were somewhat puffy. No fever was present. The urine contained blood, albumin, and casts. Over the apex of the right lung was found percussion impairment front and back, and sharp crepitations in front without bronchial breath sounds. A week later there were small râles over both backs of a somewhat consonating quality, and impairment on the right side, clearing after cough. At the end of a further week the chest was clear both sides, and remained so, though albumin and blood persisted for a considerable period thereafter.

Bronchiectasis

This disease, most commonly seen in childhood or adolescence, simulates well-established rather than early phthisis; it affords, nevertheless, a very common stumbling-block in the diagnosis of pulmonary tuberculosis, and

as such merits our careful consideration here. The condition is, the writer would insist, far more common in its slighter grades than is generally held, and leads to happenings which are very subject to misinterpretation. Thus, in the writer's opinion, most of the broncho-pneumonias of adults, and also many cases of 'basal bronchitis,' are developed in lungs already damaged, and the seat of a bronchiectatic or bronchiolectatic process. So often, in such cases, careful questioning will establish a history, and careful investigation show evidence of permanent changes, that in the remainder a similar underlying cause may often be presumed. Only those who have worked in a children's hospital can properly appreciate the frequency with which broncho-pneumonia leads to permanent changes at the lung bases. In cases that die a bronchiolectasis can very commonly be demonstrated when looked for, and in cases that recover, impairment and crepitations persisting for weeks, or months, or even permanently, after the fever and constitutional symptoms have subsided, give clear indication of this condition. Such children return, not infrequently, with 'attacks' on the damaged lungs, sometimes a mild infection associated with bronchitis, but not infrequently a pneumonia of quiet type with less constitutional and respiratory disturbance than is usual in a 'primary' attack. The writer feels confident that all or most of the cases described of recent years as "broncho-pneumonia of long duration occurring in children and young adults" (to give the title of one paper!) were of this nature, even though the signs, as may happen, appear to entirely clear after the attack. As result of a series of such attacks the lung disease will generally reach sufficiently near the surface to give permanent physical signs, where before it needed a lung 'congestion' to convey these signs to the stethoscope.

Bronchiectasis, or bronchiolectasis, for it is often an

affection of small tubes, commonly dates from a broncho-pneumonia, often the complication of whooping cough or measles in early childhood; occasionally it is left behind after a croupous pneumonia. In the former case it is usually double, though one lung is often more notably damaged than its fellow, and affects the 'broncho-pneumonic area'—that is, the base of the lower lobe extending round the axilla towards the front. The amount of accompanying fibrosis may be much or little. A history of antecedent pneumonia, and often of subsequent chest 'attacks,' and practically always of chronic cough, is often of considerable help in deciding between bronchiectasis and tuberculosis in a difficult case. Among forty cases of bronchiectasis in children collected by the writer only three affected the lung apex; the rest were basal, though they often involved more or less the whole lung, most commonly on the left side.

The main points likely to be of value in differential diagnosis are as follows:—

1. The **history**, as already mentioned, and this must be obtained with accuracy and in detail. We cannot afford to overlook this help in cases where the diagnosis is in doubt.

2. The **lung distribution**, for the most part apical in tuberculosis, and basal in bronchiectasis. It is thus with basal tubercle (see also p. 89), the outcome as a rule of hilus tuberculosis (*q.v.*), that confusion is likely to arise. Characteristic of bronchiectasis is a 'broncho-pneumonic distribution' on one or both sides, extending round the base from back to front. Tuberculosis is rarely found confined to both bases, and if unilateral is apt to appear over the upper lobe in front as well as at the base behind.

3. The **physical examination** over the diseased lung often gives us but little help in diagnosis—the signs may be identical with those due to tubercle, though

'cavity signs' are decidedly rare in bronchiectasis, and if present should give a bias against this disease. But it is elsewhere in the chest that distinctive signs must be sought. Thus in tuberculosis the 'reflex bands' (p. 34) will be present, but in bronchiectasis absent; in tuberculosis, particularly of the 'hilus' type, there will be notable narrowing, generally double, of Krönig's isthmus; in basal bronchiectasis the apical resonance is, as a rule, but little reduced: the presence of parasternal and paravertebral impairment pointing to glandular enlargement will be points in favour of tuberculosis.

X-ray examination may give useful information, but is often not decisive. Dilated and thickened bronchial tubes may, indeed, show clearly in a skiagram, or saccular cavitation stand revealed. But bronchiectasis is also often associated with chronic tuberculosis, and, moreover, a dilatation of the smaller tubes with but little thickening of their walls, may show nothing distinctive in the plate. In the diagnosis between basal phthisis and bronchiectasis this latter point may be of value (see Case on p. 87) since a basal tuberculosis giving signs at the surface is likely to demonstrate widespread and advanced disease in a radiogram.

4. Good general **nutrition** and absence of constitutional disturbance may help to give the clue in a case whose widespread distribution could hardly admit, on these grounds, of a tubercular explanation. **Finger clubbing** in bronchiectasis is either of considerable degree, or, in about half the cases, absent altogether. In tuberculosis of similar extent there will always be some clubbing, but this will not amount to more than the usual characteristic curving of the nails.

5. **Sputum** examination must be thoroughly carried out, and in this respect it must not be overlooked that a basal bronchiectasis and apical tuberculosis may be present in the same patient. A basal tuberculosis giving

signs will generally reveal tubercle bacilli to persevering sputum examination. Offensive sputum is characteristic of bronchiectasis, but this may be, as already mentioned, the accompaniment of a chronic tuberculosis. The bronchiectatic sputum which separates into three layers is a text-book commodity, and must only be expected on selected occasions. **Hæmoptysis** is a symptom which is common to both diseases; its occurrence in bronchiectasis, even to large amounts, has not been sufficiently recognised by the profession.

The characteristic instability of pulse and temperature in tuberculosis may give useful information, whether by their presence or absence.

Bronchiectasis simulating Tubercle

An officer on active service, aged 31, one morning expectorated blood-stained phlegm, and this was repeated a week later. Cough and sputum continued from this time; he felt "nervy," depressed, and "used up."

Examination revealed good nutrition, and no clubbing. The nose showed chronic rhinitis and deflected septum, with flat alae and a tendency to blocking. Pharynx granular. *Chest.*—Reflex bands present (? due to nasal disease). Apices of normal width, impairment at left base behind, with fine breezy crepitations and evidence of adherent pleura.

Bronchiectasis was suspected and a history inquired for. It was then ascertained, with the help of old letters, an aunt, and a former medical attendant, that he had "double pneumonia and bronchitis" at the age of five years, and this had repeated itself with whooping cough two years later. After this several "specialists" reported his condition tuberculous, but one spoke of "a cavity in the left lung not, in his opinion, tuberculous," and for two years he wintered on the south coast, recovered, and had remained well save for occasional bouts of cough and morning expectoration.

Repeated sputum examination failed to reveal tubercle bacilli; a radiogram showed heavy root shadows, and some small translucent areas like dilated bronchi in the perihilar region, but no shadowing at left base, a point which was strongly against basal tuberculosis, and thus evidence in favour of a bronchiectasis of small tubes without notable thickening.

Six weeks later cough and sputum had disappeared and he felt well. After a further two months there were found fewer moist sounds at the left base, but a few crepitations on the right side about the angle of the scapula.

A year later he was well, had no cough or expectoration, and the physical signs consisted only of slight percussion impairment over both bases behind, with a few crackles at the left base.

Tuberculosis complicating Chronic Bronchitis

Phthisis is very apt to be overlooked when it occurs in a patient the subject of chronic bronchitis of some standing. The wasting which arises may be mistaken for the wasting common in the later stages of chronic bronchitis, and the symptoms may otherwise present nothing distinctive. On examination, emphysema and râles are found over the chest and, in addition, an alteration or concentration of signs at one apex. Slight impairment to light percussion will be found, and here the râles will be more concentrated, and persist or increase after cough; creaking or croaking rhonchus may be heard, or small râles may be present at this point alone, and soon a broncho-vesicular quality is added to the breath sounds. The bronchitic type of hilus tuberculosis will be referred to under that heading (p. 101).

A man, aged 52 years, gave a history of winter cough with expectoration all his life, and of increasing dyspnœa during the past twelve months. Five years ago he vomited blood. The patient looked old for his age and his face unduly lined. The pulse tension was not raised; the heart sounds flapping and reduplicated, the apex beat in the nipple line. There was well-marked emphysema, and râles over both sides. At the left apex the percussion note was impaired front and back, the breath sounds feeble and of blowing quality, but no characteristic added sounds were present. The temperature fluctuated between 98° and 99° with occasional rises to 99·5°. Later he developed a small pleural effusion and tubercle bacilli were found in the sputum.

In those cases of emphysema and bronchitis where a superadded tubercular infection is suspected, the X-rays are of especial value for diagnosis, since the distension of the lungs which tends to mask the physical signs only brings out more clearly the distinctive shadows on the radiographic plate. This is referred to again on p. 132.

Tuberculosis simulating Asthma

It happens sometimes that pulmonary tuberculosis starts under the guise of a typical asthma, and this may occur both in apical phthisis and with disease of hilus type (p. 101).

A clerk, aged 40 years, had suffered with loss of weight and nocturnal dyspnœa during the past eight months; the attacks started at 2 or 3 a.m., lasted an hour or more, and ended with scanty clear expectoration. Two years formerly he had suffered with similar attacks during four weeks only.

Nutrition was good, the pulse 88. Nasal respiration fairly clear. The chest showed some emphysema; there was slight impairment to percussion over most of the right lung in front and over its apex behind, blowing breath sounds and increased vocal resonance at the apex, and a few clicks and râles both front and back. At the left apex also there was slight impairment and a few râles in the lung below. Thus the physical signs were those of a tuberculous lesion. Repeated examination of the sputum failed to reveal the tubercle bacillus, but a year later his weight had dropped still more and the lung signs had extended somewhat further.

The simulation of asthma, it will be seen, is mainly in the symptoms, the signs are those of tubercle, but generally tubercle of a quiet variety, with but few moist sounds, and masked in many cases by emphysema and perhaps by bronchitis. A mistake is very likely to be made where suspicion of the condition is not aroused.

Basal Tuberculosis

In examination of the lungs the bases must always be completely exposed and thoroughly examined. Not very rarely they are the point at which physical signs first or mainly appear in cases of pulmonary tuberculosis. "It must be insisted," remarked Fränkel, "that the earliest appreciable physical sign of lung tuberculosis is by no means always met at the apex. Not only in children, in whom often the middle and lower parts of the lung are earliest attacked, but also in adults, can the process begin at other points, for instance in the

middle lobe of the right lung, or in one of the lower lobes. One may not, therefore, omit to examine any part of the thorax, particularly the lateral wall."

Basal tuberculosis is generally divisible into two fairly well-marked categories.

1. Most commonly basal tuberculosis is basal to appearance only, the rest of the lung being filled with disease which has not yet reached the surface. This is a condition which is characteristic of hilus tuberculosis (*q. v.*), whether in child or adult; the disease spreads out from the roots in all directions, and meets the surface, sometimes over the front of the chest, sometimes in the axilla, but not infrequently at the base. At a later stage, in a progressive case, the whole lung may show signs of disease, and crepitations will soon reach the surface at some point, perhaps again the base, on the opposite side also.

2. Cases starting as a tuberculous lobar pneumonia, and later becoming subacute or chronic, and cases where a basal pleurisy has tended to concentrate the disease to this point. For the differential diagnosis of basal tuberculosis from bronchiectasis see pp. 85 to 87, and the case described on p. 87.

HILUS TUBERCULOSIS IN THE ADULT

In the first edition of the present book the writer was content to devote a couple of pages to the subject of hilus tuberculosis in the adult—the condition did not then appear to him of sufficiently frequent occurrence or distinctive character to merit a fuller recognition. But the war, with its stress and strain, has rendered common a condition which formerly appeared to be rare; or perhaps it may be that the writer, having of recent years learnt to recognise the condition in its early stages, now finds it more prevalent on account of his improved vision. Both these explanations are probably valid; certainly increased recognition of a disease so often and so easily overlooked as is hilus tubercle must tend to an altered opinion of its prevalence. As to its war-time extension, it can hardly be surprising if the long hours, mental anxiety, scrapped meals, and often too conscientious rationing among war workers, particularly of the educated class and female sex, should often reactivate the old slumbering foci of a childhood infection. For that, in the writer's opinion, is the true meaning and origin of these cases, and their common association with tuberculosis of chest glands, and close identity with pulmonary tuberculosis as it occurs in childhood lend strong support to this view. The following pages, based on the study of a large material, represent the writer's penance for his former comparative

neglect of this most important and interesting variety of disease.

And first let it be stated in general terms what we must understand by hilus tuberculosis, for the expression may convey but little meaning to those who are only conversant with disease as it occurs in the adult. Hilus tuberculosis is the term applied to disease which starts in the deep parts of the lung around its root or hilum, and which tends to spread outwards along the bronchi and vessels in a fanwise manner, and bilaterally; in contradistinction to 'phthisis' or 'apical phthisis,' where disease takes the form of a localised infiltration at or near the apex of one lung. Hilus tuberculosis is the common form of tubercular lung disease in childhood (see Part II of this book), when it starts in the root glands, and creeps outward along the lymphatics surrounding the bronchi and vessels; involving at times the lung parenchyma, and then giving rise to symptoms, but often remaining peribronchial, and dying down, or becoming latent, after a varied amount of spread. In all adults the scars of these early disease processes are visible in the X-ray plate, but they occasion no symptoms, and give rise to no physical signs. It is only when an exacerbation of disease occurs and gives rise to fresh symptoms and signs, that the term hilus tuberculosis becomes admissible and necessary in the adult.

Prelude. Let us prelude the symptomatology of the subject by short reference to a class of case which is probably familiar to most physicians—I refer to hilus tuberculosis of broncho-pneumonic type. It is no uncommon experience to meet, perhaps in a hospital outpatient department, a patient, often a young female adult, presenting manifest evidence of advanced tuberculosis—pallor, with a bluish flush on cheeks and lips, wasting and asthenia, with clubbed nails and sweating skin—and yet to find that the chest presents astonish-

ingly little evidence of disease to ordinary physical examination. There may be noted, perhaps, a dulled percussion note over both sides, and breathing of a distant blowing type, but no adventitious sounds of any sort or character to give the usual decided evidence of advanced disease. The case has, perhaps, been examined constantly for months, yet, with the patient slowly dying before his eyes, the doctor has been quite unable by stethoscopic signs to establish the diagnosis. There flits through his memory, perhaps, the aphorism of Gee: "The absence of physical signs of disease, in some cases of slowly progressive pulmonary consumption, ending in death, is most remarkable," but this does not help to resolve the problem.

It is cases such as these that have led physicians to describe a form of tuberculous broncho-pneumonia occurring without crepitations, an error to which the writer gave credence for many years, though not without frequent doubts and misgivings. "Tuberculous broncho-pneumonia," remarked Isambard Owen, "is capable of advancing slowly without giving rise to any moist sounds at all." Yes, but later this experienced clinician himself supplied the key to the problem, though one cannot help doubting whether he was fully conscious of its applicability to his own former statement. "None of our methods of physical examination," he said, "completely explore the lung below a certain depth, and owing to accidents of topographical position, extensive advance may be going on without affecting the surface signs in any degree. I do not mean that this is common, but it is not so rare that the possibility can be neglected." Where it is neglected, not infrequently steps in the radiologist, and a good X-ray plate exposes a condition of advanced central lung disease which may be not a little surprising and humiliating to the unwary physician. Those who have had experience of lung

tubercle in children should be less easily deceived by the want of correspondence between surface signs and extent of disease. Yet these also may fail to realise that hilus tuberculosis, so common in the child, may also be met with in the adult. Let us consider in fuller detail the symptoms and signs of the disease as it occurs in adult life.

Symptoms. The symptoms cannot be said clearly to differ from those of apical phthisis already described under that heading (p. 7). There are, however, certain common complaints associated with these cases and but seldom the accompaniment of early phthisis. Particularly, **shortness of breath** on exertion is a symptom which is often prominent, and due in some cases to slowly spreading peribronchial disease, and in some to the emphysema and bronchitis which are occasional complications. **Chest pain** is also a fairly frequent complaint, not in the shoulder as commonly in phthisis, but in the central regions of the chest, sternal, or spinal, or at the bases. No small number of my cases have suffered from what has been described (and often treated) as a "nervous breakdown"—in other words **neurasthenic symptoms** have been prominent. Cough is often but slight, save in the "bronchitic type" of case, and unaccompanied by sputum. When sputum is present it appears often to be of bronchitic origin, and the tubercle bacillus is rarely found in it. Pulse and temperature often disclose little or no change, save in the later stages of the disease; at most an occasional subfebrile disturbance gives evidence of auto-inoculation.

Characteristics of Hilus Tuberculosis

Before describing the physical signs of the disease, it may be useful to state shortly the main characteristics whereby the condition differs from the ordinary case of apical phthisis.

1. **Its bilateral nature.** Whatever stethoscopic signs appear at the surface in these cases, and wherever these signs may be found, the central disease is always bilateral, though stress may fall for a time more potently on one or other lung. Its bilateral character generally reveals itself in two ways—firstly, movement of the two sides is very commonly equal; secondly, there is a marked shrinking of both apices, as evidenced by measurement of Krönig's areas (Fig. 11, p. 70). This double apical contraction may be considered the sign-manual of hilus tuberculosis, and its occurrence renders 'topographical percussion' the royal road to its detection. Indeed, apart from the definite evidence derivable from this source, it would often be impossible to detect hilus tuberculosis in any but its latest stages. For its bilateral character necessarily deprives us of that contrast between the two sides of the chest on which we are wont so largely to rely in the diagnosis of tubercle. This would be of less importance were disease within reach of the stethoscope, but this is only so in its later and more hopeless stages; in early disease, and for the greater part of its progress, or throughout its course in cases which recover, stethoscopic changes are commonly absent over the whole of the chest. It is for this reason that the disease is so easily missed, and that especially so where undue reliance is placed on stethoscopic signs.

2. **The atypical location of surface signs.** The next characteristic of hilus tuberculosis consists in the peculiar location of the stethoscopic signs of disease when these appear at the surface of the chest. In contrast to the apical crepitations of phthisis, the first signs in hilus tuberculosis may appear at almost any point of the chest, often the base behind, or the middle of the upper lobe in front, or, not infrequently, in the axilla. Since disease spreads out from the root fanwise along the lung framework towards all points

of the surface, it is obvious that it may first reach the stethoscope of the physician at almost any point.

3. The characteristic spread of stethoscopic signs over the lung surface. Similarly, it must be expected that when the disease has reached the surface at one point, it will not be far from the stethoscope at many other points also. Hence it is characteristic of hilus tuberculosis that having once reached the surface of the lung, unless disease becomes arrested, the signs, crepitations and the like, tend to spread quickly, often within weeks, over the greater part of that side front and back. On this account it is not uncommon to meet with cases of 'clinically unilateral' tuberculosis involving the whole of one lung, and apparently sparing the lung on the other side. This unilaterality is, however, apparent only, and a radiogram will reveal disease of little less extent, though often of much lower activity, through the other lung also. It is among these cases, especially, that pneumothorax treatment has achieved so notable a success, for the quiet lung is often found able to stand the strain of increased function while the more diseased organ is collapsed. Of fifty-one left-sided cases of pulmonary tuberculosis submitted to this operation by Brauer, 33 per cent. appeared to be cases of hilus origin in which disease had spread from the root outwards into the lungs (Straub and Otten); nearly all the writer's pneumothorax material has been of similar nature.

Physical Signs in Hilus Tuberculosis

So much for the three main characteristics which tend to mark down the 'hilus' origin of a case of pulmonary tuberculosis. Let us now consider more closely the physical signs as these occur in the average or typical case; thereafter some characteristic variations from this average type will receive separate notice.

A patient comes to his physician with symptoms suggestive of tuberculous chest disease, but on examination no signs are present pointing to the unilateral apical infiltration characteristic of phthisis. How is the presence of disease deep in the chest—central or hilus tuberculosis—to be excluded? If this disease is present we shall find the following signs:—

Inspection.—On inspection there will probably be nothing to catch the eye, possibly an inspiratory 'dimpling' below the clavicles.

Percussion.—On percussion the reflex bands of impairment over the backs illustrated on p. 35 will be present. In addition there may be a slight difference of percussion note between the two sides front and back, and this is often against the right side. There are also present, in many cases, the increase in parasternal and paravertebral impairment which are indicative of glandular involvement (pp. 240 and 245), and attention must always be paid to these regions. The parasternal impairment may extend in adults some 4, 5, or even 6 cm. outside the sternal margin on one or both sides, the normal being some 2 or $2\frac{1}{2}$ cm. (about 1 inch); the paravertebral area, more commonly present than the parasternal, may reach 6 or 7 cm. from the spine on the right side, and it is generally normal or of much less extent on the left (see p. 247). These evidences of glandular enlargement are, however, very commonly missing.

Next, and most important, we find a striking abnormality in the size of Krönig's isthmus at the top of the shoulder on both sides. In the normal chest this isthmus does not fall below 4 cm. in width; in cases of central lung tuberculosis it is found to be considerably reduced, very commonly to $2\frac{1}{2}$ cm. on the two sides, (see Table on p. 72 and also Fig. 11, p. 70). By means of this evidence we gain information of importance in two directions. Firstly, we learn that it is no healthy

chest we are examining—though nothing else can be found at the surface we may be confident that some central disease, or the scarring from disease, is present, and when the narrowing is considerable and bilateral there is a strong presumption that we are dealing with a case of hilus tuberculosis. Secondly, the condition of Krönig's isthmus is often of assistance in the decision between apical phthisis and disease of hilus type, though borderland cases may be found in which the verdict must remain open. In phthisis, as a rule, the retraction of the isthmus is less marked—often only to $3\frac{1}{2}$ cm., sometimes as large as 4 cm. (see Table on p. 72), and it is, in early stages, unilateral. When the opposite apex is attacked the isthmus will of course show narrowing on both sides, but then the apical character of the disease is generally sufficiently obvious on other grounds. In hilus tuberculosis the narrowing of Krönig's isthmus is double from the earliest beginning of symptoms.

Palpation. When chest movement is tested it will generally be found, contrary to our experience in phthisis, that it is equal on the two sides, at least in early stages. Indeed, equality of movement, with bilateral narrowing of the apical resonance, and absent stethoscopic signs form together a very characteristic picture of hilus tuberculosis. In certain cases, however, the stress of disease may fall more decidedly on one lung, particularly the right, or decided pleural changes may occur; then, of necessity, a unilateral limitation of expansion is present and the characteristic balance of movement is lost.

Auscultation. In all early cases stethoscopic signs are entirely absent—at the most the lung bases may exhibit some fleeting crepitations of doubtful, and probably heterogeneous, nature; these will receive further consideration in Part II of this book (p. 242).

Only with well-advanced disease do fixed signs appear

at the surface, and that generally over a wide area at once. This may be the middle of the lung in front, the axillary region, or the base behind—nearly all basal cases, with exception of those starting with pneumonic disease, prove to be examples of hilus tuberculosis. The first stethoscopic signs of disease usually consist in 'granular' breath sounds heard over a large area of the chest wall. As disease gets nearer and nearer to the surface, the 'deep crepitation' origin of these granular sounds (see p. 59) becomes more and more apparent; finally, frank moist crepitations appear close under the stethoscope. So much for the signs of more advanced disease, and while speaking of these, it may be remarked that cavitation when it occurs in hilus tuberculosis does not do so at the apex as in phthisis. Among seventeen advanced and, clinically, one-sided cases investigated by the writer, in eleven cavitation, mostly of considerable extent, was evident to physical examination. Of four right-sided cavities, three were in the axillary region, and one at the base; among the remaining seven cases which occurred on the left side, in six cavitation was in the middle of the upper lobe just outside the heart; in one it was basal. Deep cavitation, outside the lung root and discoverable only to X-ray examination, is not infrequent in these cases.

There remains still one point to mention under stethoscopic signs, and that is the very common occurrence of attacks of dry pleurisy during the course of hilus tuberculosis. This is usually basal in location; and it may occur sometimes at one base, and sometimes at the other in a quite irregular manner. For this reason it is a very common find in these cases that the tidal expansion at the base fails on one side or both; in the absence of considerable intrapulmonary disease, and also of marked emphysema, this can usually be taken as evidence of adhesion of the pleural surfaces (p. 75).

This is particularly the case, if, as occasionally happens, tidal movement is still present over some part of the base. [For the **Radiological** characteristics of hilus tuberculosis the reader is referred to p. 122.]

Aberrant Types

Having indicated the usual symptoms and physical signs in average cases of hilus tuberculosis, it is necessary to make separate mention of certain variations from the normal type.

1. **Hilus tuberculosis with cervical lymphadenitis.** There occur cases, and these have been particularly frequent during the war, where hilus tuberculosis is associated with enlargement of lymphatic glands, not only in the chest, but also in the neck, axillæ, and sometimes in the abdomen and groins. The lung condition in these cases usually appears quite secondary in importance to the glandular disease, and the chest picture is similar to that found with enlargement of chest glands in the child (*q. v.*). In two of the writer's cases there was associated enlargement of the thyroid gland. Attention was first called to the occurrence of such cases by Philippi in the year 1911; and his description of the condition is both full and accurate. He insisted on the characteristic parasternal and paravertebral dulness in these cases (see pp. 240 and 245), and attributed the latter sign to inflammatory infiltration surrounding the diseased glands, or in some cases to the presence of an atelectatic zone (see remarks on pp. 246 and 247). Among other signs and symptoms of the disease, he considered especially characteristic the occurrence of fleeting marginal pleurisies, spasmodic intermittent subfebrile attacks, and the presence of lymphocytosis.

The writer has now had five adult cases under his care in which glandular and hilus tuberculosis were associated with enlargement of surface glands in the neck and

elsewhere; more commonly the lymphadenitis is confined to the intrathoracic gland groups. To the X-rays these cases generally showed a widespread peribronchial shadowing in addition to obvious enlargement of glands, both tracheo-bronchial, and about the lung roots. With recent or active disease, where the process has not yet proceeded to caseation, the enlarged glands may, as Philippi has remarked, present but little shadowing on a radiogram.

2. **Hilus tuberculosis associated with asthma and bronchitis.** In many cases of hilus tuberculosis of chronic 'peribronchial' type there is a tendency to attacks of bronchial catarrh, and the recurring cough and sputum are often, in all probability, of this origin. Certain cases may indeed present all the symptoms, and many of the signs, of a case of chronic bronchitis with emphysema, and often with asthmatic attacks. As a rule there are certain points which direct attention to the underlying tubercular disease. The history is likely to be of short duration, and wasting will generally be a prominent symptom. Often one or more brothers and sisters of the patient are pronouncedly tuberculous. The pulmonary signs may be, in most respects, typical of chronic bronchitis, though often with a bias of signs against one side of the chest. But it is to a narrowing of Krönig's isthmus that we must look for more definite evidence of central disease. In chronic bronchitis it might well be expected that Krönig's isthmus would commonly, owing to the presence of emphysema, show a more or less striking enlargement. In some cases, truly, the apex may be as wide as $5\frac{1}{2}$ or even 6 cm., or it may maintain the normal 5 cm., but much more frequently the raising of the shoulder girdle, and possibly also the development of some amount of peribronchial fibrosis, tend to reduce the isthmus to a figure rather below the normal, often to $4\frac{1}{2}$ cm. or 4 c.m. (see Table

on p. 72). In some cases where the isthmus is diminished to $3\frac{1}{2}$ cm. doubt will be felt whether the condition belongs to the category of simple bronchitis or not. Where the reduction is to 3 cm. or $2\frac{1}{2}$ cm. there is decided evidence of central disease whether present or recently past, and, in the absence of a history of exposure to dust diseases, this will probably be hilus tuberculosis. The possibility of tubercle masking under the guise of asthma or chronic bronchitis must always be borne in mind.

3. **Hilus tuberculosis of broncho-pneumonic type.** The third group which calls for a few words of separate mention has already received illustration at the introduction of the subject of hilus tuberculosis (pp. 92 and 93). It stands in so strong contrast to the usual type of hilus disease, which is of notably chronic and intermittent course with a strong tendency to healing, that the identity of the two conditions finds evidence solely in their similar central location and mode of spread, and thus in the signs which they present at the surface of the chest.

Differential Diagnosis

When we come to consider the differential diagnosis of hilus tuberculosis, we look to the physical signs for information in two main directions. On the one side the healthy chest, or this with some amount of bronchial catarrh, may have to be excluded, on the other a diagnosis must be attempted between hilus and apical tuberculosis.

1. To introduce **the healthy chest** under the heading of 'Differential Diagnosis' may seem at first sight a strange irregularity, or even be condemned as an indiscretion. Nevertheless it must be recognised that it is in this direction that errors in diagnosis have mostly lain; hilus tuberculosis in its early stages has commonly been entirely overlooked, and the chest passed as healthy,

or the symptoms have been attributed to a simple catarrh. This has arisen in all cases from failure to make a complete examination—too commonly contrast percussion is but carelessly performed, Krönig's isthmus is not mapped out and measured, no attention is paid to parasternal and paravertebral percussion, and the tidal movement at the base is entirely neglected. If all these points were included, as they should be, in the examination of the chest, it would be practically impossible to mistake the chest of hilus tuberculosis for the normal. To those who omit these signs the 'normal chest' can merely be one that presents no obvious area of dulness, gives equal movement on the two sides, and presents no changes to stethoscopic examination. But the chest of early hilus tuberculosis shares with the normal chest all these negative points, hence these are useless in its diagnosis. The points on which the differential diagnosis must be based may be shortly indicated as follows.

	Normal Chest.	Early Hilus Tuberculosis.
Reflex bands (p. 35) . .	Absent.	Present.
Krönig's isthmus (p. 67) .	Of normal size.	Contracted on both sides.
Parasternal dulness (p. 240) .	Absent.	Present in some cases.
Paravertebral dulness (p. 245) .	Absent.	Often present on the right side.
Tidal movement (p. 73) .	Of normal amount.	Often absent or reduced on one or both sides.

And now, having discovered, through the evidence of some of these signs, that the chest under consideration is outside the normal, what proof have we that the malady is of tuberculous causation? Often very little, it must be confessed. For hilus tuberculosis will commonly smoulder for years without any very characteristic symptoms, and tubercle bacilli may be absent from the sputum

almost throughout its course. Where there are definite evidences of glandular enlargement, whether of tracheo-bronchial glands, shown by widened parasternal impairment, or of bifurcation or root glands, shown by paravertebral dulness, and these signs persist, there is, to be sure, very high probability that the condition is tubercular. Where, however, the only definite sign is a double narrowing of Krönig's isthmus, though we know that this indicates a central lung lesion, the evidence of its tubercular causation is very commonly lacking. True, pathology has demonstrated the prevalence of tuberculous foci at the roots, and has supplied no other common explanation of chronic inflammatory changes in this region. Moreover, an appeal to the X-rays may disclose to view decided peribronchial thickening, and perhaps some nodular shadowings, changes which, in the absence of other obvious causation may, perhaps, be accepted as evidence of the inroads at some time or other of the tubercle bacillus (see remarks on pp. 120 and 121). But the question of their present activity, and their relationship to the patient's symptoms, may often be open to doubt. Let it be, however, clearly understood that the obsolete hilus disease of childhood does not suffice to explain a narrowed apical resonance in the adult—the changes of growth supply a fully expanded lung in such cases. Experience of the persistent quiet activity, and intermittent spread, of tuberculous processes at the root of the lung, conjoined with the symptoms and signs described above, will supply an element of 'high probability,' and with this we must often be, for the time at least, content.

Moreover, we shall have clear recollection of patients with similar physical signs who later passed over into the region of proved tuberculosis. Our position is little worse than in the diagnosis of apical phthisis in the absence of bacillary sputum, again a matter of probability

of a high degree. "Given apical changes," says Turban, "without previous pneumonia, and when the inhalation of dust can be excluded, then the diagnosis is almost certain." And the same may be claimed for central or hilus lung disease. A patient with narrowed apices and suggestive symptoms, but with no history pointing to dust inhalation, may be regarded as probably suffering with active peribronchial tuberculosis; a patient with narrowed apices and no symptoms is probably the victim of arrested disease of similar causation. These probabilities may be increased or diminished by the application of some of the special diagnostic methods referred to in the later pages of this volume.

2. The differential diagnosis of hilus tuberculosis from **apical phthisis** is, as a rule, simple and straightforward; in some cases, however, particularly with the advance of disease, the two conditions become difficult or even impossible to distinguish. Indeed, it must be admitted that between the two characteristic types there exist many intermediate pictures of disease which do not clearly conform to either, or are conceivably a blending of both. But in spite of this occasional failure of type the differential diagnosis can commonly be made, and it is always worth the attempt on account of the differing course and prognosis in the two conditions. For hilus tuberculosis is nearly always of peribronchial type and extreme chronicity; tending to spread over wide areas, often with greater mechanical than constitutional disturbance; becoming stationary for long periods; showing occasional activity, often of a pleuritic nature, and then again dying down. Smouldering always and extremely difficult to quench; but, only at long last, and in exceptional cases, breaking into a conflagration of such extent as to threaten life, and then usually at so advanced a stage as to render the outlook hopeless. The cases of broncho-pneumonic hilus disease cited above are

notable exceptions to this usual course, and fortunately but rare ones.

In all these particulars of its spread, it stands in contrast to apical phthisis, of which the immediate prognosis is always more serious and uncertain, and which moves forward more rapidly, accompanied by fever and constitutional disturbance, albeit with periods of arrest, towards its ultimate ending in death or cure.

Already, under the heading of the characteristics of hilus tuberculosis, some of the main differential points between it and apical phthisis have necessarily been laid down—its bilateral character from the beginning, its appearance at other points than the apex of the lung, and its spread over a wide area of the chest wall once the surface is reached. In practice the differential points may be shortly set out in tabular form as follows.

	Hilus Tuberculosis.	Phthisis.
Inspection.	Nothing characteristic, but any change, such as flat chest or emphysema, will be bilateral.	Flattening or hollowing, and lagging, of one apex in advanced disease.
Percussion.	Perhaps slight 'contrast' impairment on one side, generally the right.	Decided impairment at one apex.
	Parasternal or paravertebral dulness or both.	Neither.
	Bilateral narrowing of Krönig's isthmus.	Unilateral narrowing of less extent.
Palpation.	Movement equal, or nearly so, on the two sides.	Unilateral deficiencies of movement.
Auscultation.	No stethoscopic signs at earlier stages, at most fleeting pleurisies or transient basal crepitations; then granular breath sounds over a wide area, changing to crepitations. Wide areas involved, often the middle or base of the lung. Often the whole of one lung involved before signs appear on opposite side.	Fairly early stethoscopic signs at one apex, soon crepitations here, later at opposite apex.

So much for the differential diagnosis between these two forms of pulmonary tuberculosis, or rather between fairly typical cases of each. That many borderland cases occur whose classification is doubtful, the writer has already indicated, but the classical case of hilus tuberculosis at a characteristic stage clearly belongs to a type by itself. Where an element of doubt in their differentiation must sometimes exist, is in the eventual progress of certain early examples of disease—whether these must necessarily be regarded as on the way to become hilus tuberculosis as we ultimately see it, or whether their future advance might be on the lines of an apical phthisis. This is a matter on which there can exist no great certainty at present. For these earliest examples might possibly represent, in some cases at least, a ' subtuberculous ' stage from which both phthisis and hilus tuberculosis may later emerge, and the writer has not shut his eyes to this possibility.

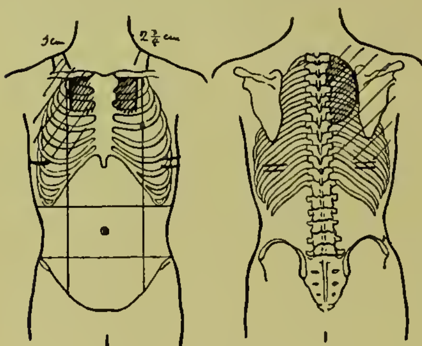
But, for one of these early cases, with double narrowing of apices, to progress towards apical phthisis, it would be necessary for this apical contraction to open out. This the writer has never known to occur under observation, unless perhaps partially in a single case. As a rule the apices tend to become narrower with time, whether with a spread of disease in a progressive case, or with fibrotic changes where repair is taking place. If there is any truth in the attractive theory, elsewhere outlined, that there exists a true etiological distinction between the two conditions, the one being a spread from old existing foci of disease, and the other a reinfection from without, then clearly there could be no early stage common to both. In the writer's opinion facts and theory here run a parallel course, and such evidence as there is tends to support the view of a separate identity for hilus tuberculosis and apical phthisis.

EXAMPLES

Hilus Tuberculosis with enlarged Tracheo-bronchial and Root Glands

C. R. 26. Weakness 12 months, tired after work, sweats at night, has lost 2 st. of weight in past 12 months. Cough with expectoration. Father and two brothers consumptive (see H. R. below). Thin and pallid face, body muscular and well covered. Pulse 80, no clubbing, skin cool.

Chest. Reflex bands present (p. 35), chest over-expanded, movements equal. Slight contrast impairment over right lung. Double parasternal, and right paravertebral dulness. Adherent pleura right base in front. Both apices narrowed. No adventitious sounds, slight emphysema.



To illustrate case of C. R.

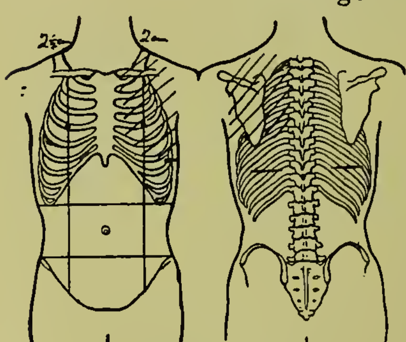
X-rays. Show increased hilum and tracheo-bronchial shadows, and peribronchial opacities with a general mottling of the lung substance, rather more marked in the right lung. Radiologist diagnoses old-standing tuberculosis, (?) subdued activity.

Hilus Tuberculosis without Evidence of Glandular Enlargement

H. R. 20 (brother of C. R. above).

Tubercle bacilli found in sputum twelve months ago and on occasions since. Has lost 7 lb. in weight in last four months. Eggcupful of expectoration daily, and often streaks of blood in it. Good nutrition and colour, pulse 72, no clubbing. Cough does not sound 'effective.'

Chest. Reflex bands present (p. 35). Movement and percussion note against left side, and breath sounds rather 'blowing,' and interrupted at this apex; no adventitious sounds. Both bases adherent, and both apices narrowed.



To illustrate case of H. R.

X-rays. Apices light up badly. Linear opacities through lungs, especially right, upwards, outwards and downwards. Pleuritic thickening at bases.

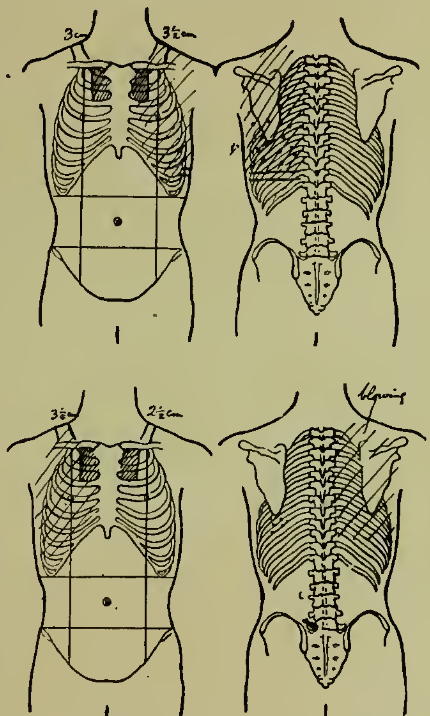
Hilus Tuberculosis in a Patient formerly treated for Cervical Adenitis

Mrs. B. 35. Eleven or twelve years ago enlargement of neck glands, treated by two operations, Bier's treatment, and tuberculin; two years ago bad attack of bronchitis and confined to bed; last two winters cough lasting a few weeks. Now has lost weight, down to 8 st. 4 lb.; a few months back 8 st. 9 lb., and years ago 9½ st. For a long time past tired sensations, aching legs; no cough or expectoration, no sweats or fever.

Thin, sallow, tired-looking, pulse 84, scars of operations right sub-maxillary region, and above right clavicle.

Chest. Reflex bands present. Movements equal.

Percussion note against left side, double parasternal dulness; breath sounds a trifle 'blowing' at both apices, more marked at left; scattered crepitations left base, tidal movement here small but present; both apices narrowed.



To illustrate case of Mrs. B.

Seen again three months later, weight had risen to 8st. 11 lb. 4. oz. Temperature had remained normal in every respect, still tires easily.

Chest. Much as before, but percussion note practically equal on two sides; breath sounds most 'blowing' at right apex behind; only a crackle left at left base, apex further narrowed, left parasternal dulness wider.

Three months later she had gained a further 14 lb. and was doing well.

Cervical Adenitis associated with Hilus Tuberculosis.

L. P. 21. Went out to France Oct. 1914; wounded March 1915, and again August, and afterwards in hospital with bronchitis. Cough continued, and in October neck glands became enlarged.

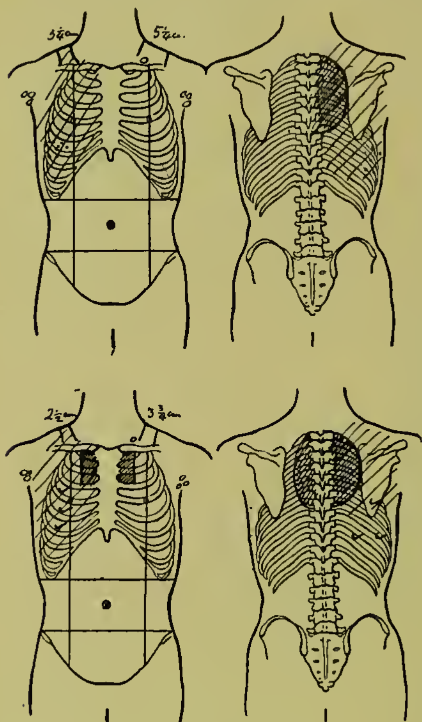
Note 4 / 12 / 15. Good nutrition and colour; large glands of soft and elastic consistency in both posterior triangles of the neck, more marked on left side, where also an enlarged supraclavicular gland; glands also large and firm in both axillæ.

Chest. Reflex bands present (p. 35); movement equal; percussion note impaired over right side, and apical resonance narrowed; some fine crepitations at right base, but none elsewhere. No enlargement of abdominal organs.

Went into a sanatorium, where temperature remained normal. Afterwards lived on a farm. Weight rose to 11 st. 10 lb. —a gain of about 10 lb.

Cough continued with a little expectoration.

Note 2 / 10 / 17. Stout and well. Cervical and axillary glands enlarged as before, also some fulness of thyroid gland. Nose and throat quite normal.



To illustrate case of L. P.

Chest. Just as at previous examination, except that there is further narrowing of the apices, affecting now the left side also; corresponding with this some paravertebral impairment has appeared over the left back. Some general râles are heard over the right chest, but no crepitations. Movement of the two sides still strictly equal.

THE SPECIAL DIAGNOSTIC TESTS

HOW TO USE THEM

In all cases coming to the physician for diagnosis we may fairly presume that he will begin with a careful note of symptoms, and will thoroughly utilise all the ordinary physical methods of examination before he resorts to the special diagnostic tests about to be described. Having got so far, he will in most cases have already achieved his aim, and arrived at a diagnosis more or less certain. A diagnosis of phthisis, be it noted, must always be, apart from the discovery of the tubercle bacillus, a matter of probability more or less great; according to the value and number of the various pieces of evidence collected together will the result come near to certainty. Thus, for example, a chronic lesion, confined to one apex, and giving such physical signs as impairment, blowing breath sounds, and crepitations, forms a picture whose tuberculous authorship is fairly well guaranteed. Here the factors are so weighty that but few are needed for a diagnosis. In other cases numerous smaller points of evidence, derived from many quarters, may make up by numbers what they lose in importance. Thus a different set of factors has to be considered in each case, and, when these are collected with the skill and handled with the knowledge which long experience gives, a diagnosis which rarely errs can generally be made from signs and symptoms alone.

It happens, however, at times that the evidence does not go far enough in one or another direction, and the

indication exists for further assistance. This must be derived from some one or other of the special tests, and their value will depend a good deal on the judgment with which they are selected. For they are in no way suited to indiscriminate use, but rather to forward the diagnosis in some particular direction in which other evidence has failed. Thus, in a case of apical catarrh we do not demand evidence of activity such as may be obtained from a fever test, but evidence, rather, for or against the pathological basis of tubercle—X-ray shadows, sputum examination, or, perhaps, proof of the implication of the lung parenchyma in the occurrence of albuminoptysis. Where, on the other hand, an old dry lesion is present and the question is mainly that of activity, we shall turn especially to such evidence as symptoms and the temperature tests can give us. Where, besides, the tubercular nature of such a dry lesion, mainly revealed to percussion, is also in question, we may add the auto-inoculation test to our list or seek for tuberculin reactions. This is a more profitable and elegant manner of utilising the special tests than in running needlessly through the gamut of ways and means; it is, moreover, less costly to the patient, which may be, at times, a matter of considerable importance. It is, then, well to ask oneself in a case where symptoms and signs still leave us in doubt, "In what particular direction does the evidence I have before me fall short?" and to apply to the patient those tests which best supply the missing evidence on which a diagnosis of phthisis must rest.

RÖNTGEN RAYS

The introduction of Radiology into the realm of medicine placed in our hands a very valuable aid to the study, and diagnosis, of intrathoracic tubercle. Indeed, in so far as early diagnosis was concerned, it might well have been expected that by the discovery of a means of visualising the disease, we had reached, at a single stride, the end of all our difficulties. This, however, soon proved itself a fallacious hope in practice, and that for two main reasons. Firstly, it is only when a deposit of tubercles has reached a certain size that they become visible to the rays, and before this stage is reached the exudation round them may supply signs to stethoscopic examination; secondly, even when the shadows of disease are demonstrable, it is often impossible to determine how far they are the result of recent disease, and how far only the scars of ancient battle so commonly visible in the lungs of civilised man. It must be added, also, that in chest radiology we are still far from having found our normal balance; the revelations of the X-rays have been so new and bewildering that we are still only beginning to interpret correctly what we see, and to adjust our judgment to the novel conditions.

The value of X-rays. Of the value of X-rays in diagnosis it is very difficult to give a just estimate. In the training of a chest physician they are, indeed, an indispensable adjunct, but after years of experience with combined X-ray and physical examination, the physician may undoubtedly arrive at a stage where the rays can help him but little in the diagnosis of early disease. He will find that in average cases he can

readily dispense with their help, and in cases where his experience, and skill in physical signs, can only bring him to a provisional diagnosis, the X-rays will, in most cases, advance him no further. But before he has reached this degree of certainty in his physical signs, the X-rays will remain a very useful monitor to keep him along the right path. Moreover, their routine use occasionally sheds unexpected light on a doubtful case, and materially assists the diagnosis; for this reason they must not be allowed to fall into neglect even in the diagnosis of early cases.

It is, however, in other respects than in diagnosis that the X-rays find their most notable utility. They will successfully 'wipe the eye' of the sceptic in cases of hilus tuberculosis lacking auscultatory signs at the surface (p. 93)—the physician who has kept in touch with radiological practice will not allow himself to fall into this trap! They will, indeed, give useful information about the extent and character of disease at all stages after the onset; particularly they will, not infrequently, help in the detection of a spread of disease into the healthy lung in cases of apical phthisis, since this may be visible in the depths before it becomes manifest at the surface. But the converse may occur, as Fishberg has rightly insisted. "The divergence of findings on physical examination and skiagraphy," he remarks, "is best seen in far advanced cases of phthisis in which a new lesion occurs in the hitherto unaffected apex. The plate does not show it until caseation has taken place, while physical exploration reveals it clearly. I have had this incontrovertible proof of the inadequacy of skiagraphy in incipient lesions repeatedly." This little corrective, perhaps needlessly soured to the palate of the radiologist, serves usefully to readjust the balance of values between X-rays and physical signs in the diagnosis of chest disease. Both are methods of physical

investigation, and, since each tends to supplement the other in various respects, it may fairly be insisted that the physical examination of a chest is not fully complete unless both methods have contributed their proper share towards its accomplishment.

RADIOGRAPHY

The study of the 'fixed' pathological changes, as opposed to the 'mobile,' is best pursued on the photographic plate, and radiography will here take precedence of screening as being decidedly the more profitable method, especially since the introduction of rapid exposures. Where possible, both processes should be combined for the diagnosis of tubercle.

Normal Tissue Shadows

It is of paramount importance that the X-rays be used with a very clear appreciation of what are the appearances in the normal chest. For this reason a radiogram taken from a healthy subject is reproduced (Fig. 14), and attention is called to the following points.

(*a*) The normal shadows at **the hilus of the lung** have given rise to much discussion. Certain writers have ascribed them in all cases to pathological changes the result of early tubercular disease; but it is well to point out that this interpretation has not obtained wide acceptance. More generally they are attributed to the large bronchi and bloodvessels, or one or other of these. Thus Dunham, Boardman, and Wolman, as the result of careful dissections, and of injection experiments with bismuth into the bronchi and bloodvessels separately, came to the conclusion that both were jointly responsible. Fraenkel and Lorcz, on the other hand, attribute the whole hilus shadow to the large bloodvessels, and claim

to have obtained some proof of this by injection of the pulmonary artery with cinnabar. Sewell and Childs appear to hold a similar view. In this country the large bronchi are generally accepted as the main cause of the normal root shadowings. This is not to deny that accentuation of these shadows is very common, or even

Taken by the Sanitas Electric Company.

Fig. 14.—Radiogram of normal chest.

universal, in adults as the result of morbid changes, but only that there exist normal root appearances apart from these.

Accepting these views, we may conclude, for the present, that the hilus shadows are due to the large bronchi and bloodvessels passing out in various directions. They are accentuated where these structures

cross the ribs or one another, and where they are viewed in high perspective; a large bronchus seen in optical section may appear as a ring, and a large bloodvessel similarly placed may well be mistaken for a diseased gland. Moreover, shadows resembling isolated tubercles may be produced by one small bronchus or bloodvessel crossing another. The normal glands are not visible, but healed glandular tubercle is very common, and calcareous and fibrosed glands are often to be seen in 'normal' chests. In town-dwellers, moreover, and those exposed to dusty occupations, the possible presence of siliceous, carbonaceous, and other deposits must be taken into account, for these may give shadows of similar distribution to those of tuberculosis.

(*b*) Passing out from the hilus in healthy chests, and sometimes visible even to the periphery, is a delicate **lung arborisation** which can only be attributed to branches of bronchi and bloodvessels. Especially noticeable are the stronger shadows or 'strands' running from the hilus directly upwards and downwards; those to the apex, generally three in number, have been said to pulsate (Schut), to be more visible during life, and especially so in conditions of pulmonary engorgement and hence to merit a vascular interpretation. Nevertheless, experience of chest radiograms soon convinces that they are, in the main, of bronchial nature. They can be seen to thicken, with a rough, irregular, or nodular outline, as a result of disease, and it is particularly around these upward stands that tuberculous processes tend to arise (pp. 128 and 131).

(*c*) The apices and other boundaries of the thorax are normally darkened by **layers of muscle and other tissues,** including, at the outer confines, part of the vertebral border of the scapula. This shadowing is often deeper on the right side from greater muscular development, but translucency at the apex varies normally,

according to Wolff-Eisner, from side to side, probably with alterations of expansion.

(*d*) The **breasts** in women cause a shadow zone over the plate.

(*e*) Fat obstructs the rays perceptibly, and in fat people shadowing may occur, especially at the base.

(*f*) The diaphragm is generally higher on the right than the left side in healthy people.

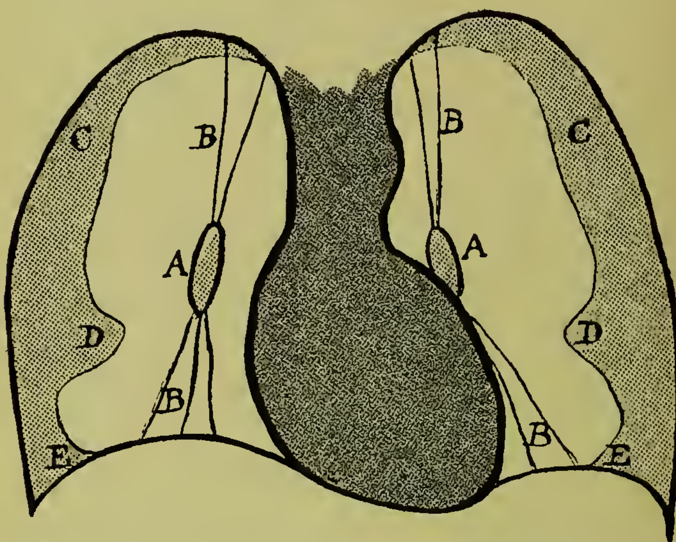


FIG. 15.—Normal chest shadows shown diagrammatically: after Francke. Letters refer to paragraphs in text on pp. 115 to 118.

These facts are conveniently embodied in a diagram (Fig. 15) on similar lines to one by Francke; the lettering on it refers to the paragraphs above.

Shadows of Disease

For the proper understanding of the radiogram in a case of tuberculosis, it is necessary that we appreciate clearly what shadows the diseased tissues may super-

impose on the normal picture. A limited deposit of tubercles, with an exudative process in the tissues, may give us stethoscopic signs, but be quite invisible on a radiogram. It is only when tubercles grow to a certain size, or coalesce, or when broncho-pneumonic processes appear, that disease becomes visible to the rays. Miliary tubercles are not perceptible, unless closely sown, when they may appear as a fine stippling; this is not improbably due to injected bloodvessels, a condition which has been experimentally demonstrated by the production of a focal reaction with tuberculin. As for isolated tubercles, L. G. Cole claims that "the smallest ones that are clearly discernible to the naked eye on the cross section, those that give the 'shotty' feeling to the cut surface of the lung, show distinctly in a radiogram having sufficient detail. It is on these tubercles," he proceeds, "that the positive diagnosis of incipient pulmonary tuberculosis by the X-rays depends." Ziegler and Krause found by experiment that pieces of tissue remained invisible until of 4 c.mm. bulk, and then were only seen clearly when near to the plate. For this reason they recommend that in the diagnosis of early phthisis two skiagrams be taken, one dorso-ventral, and the other ventro-dorsal. Caseous material casts a dense shadow with a sharp outline; fibrous tissue tends to run in lines; calcified tissue produces an intense and lumpy opacity. Large cavities appear as excavations in the lung picture; smaller ones are visible only when surrounded by a dense fibrous capsule. Cavities may readily be missed where they are filled with secretion and thus airless, or covered by thickened pleura, or screened by thick layers of lung tissue. Diseased glands give circumscribed shadows which must be distinguished from the shadows, mostly linear, of bronchi and vessels at the roots. Glands freshly enlarged and inflamed may cast no shadow on the plate.

TUBERCULOSIS UNDER THE X-RAYS. HILUS TUBERCULOSIS AND APICAL PHTHISIS

Infection with the tubercle bacillus is so widespread among civilised communities, that visible evidence of its activity must be classed among the normal radiographic appearances in the lungs of the adult. In children of school age this is even more strikingly the case (see p. 265), since disease is then often still smouldering, or has but recently become quiescent. It provides at this stage clear evidence of a 'primary' tuberculous infection, in that glandular enlargement and disease is a characteristic feature, but there also appears, in nearly all cases, an irregular thickening of the strands running out into the lung, together with isolated tuberculous deposits here and there around these (see also p. 271). In the adult these evidences remain, though time may have tended to render them, and especially the glandular involvement, of less striking visibility.

But, it will be asked, what evidence is there that these thickened strands and nodular opacities so commonly visible in the lungs are of tuberculous origin? For even though the tubercle bacillus is ubiquitous, and the majority react to tuberculin, no proof is thus supplied of the tuberculous nature of these pulmonary thickenings. It must be admitted that the evidence on this important point is all too inadequate at present, and that further research is still needed. Of the nature of the glandular shadows, and of 'nodules' representing tubercles, isolated or grouped, clinical experience has supplied abundant evidence. It is the linear shadowings whose tuberculous nature and causation is commonly challenged, and even here a few investigations can be recorded. Jordan radiographed 36 'healthy' lungs from post-mortem bodies varying in age from 4½ to 72 years, and mostly the victims of accidental death. "A

large number of sections of the hilus shadows of some of these 'healthy' lungs," he says, "have been cut and stained by Mr. Mahon; they indicate beyond the possibility of doubt that these shadows are tuberculous in nature. The appearances in some cases are practically indistinguishable from those shown in sections of an ordinary case of very chronic phthisis. There are typical broncho-pneumonic patches with small round cells and large endothelioid plates, there are extensive tracts of dense fibrous tissue, and there are the calcareous patches already referred to." Elsewhere he remarks: "Microscopical sections through these 'linear shadows' show a large excess of fibrous tissue around the bronchial cartilages. Giant cell systems are found in some cases, showing that there is actual tuberculous disease in progress." Very easily are these old evidences of tubercle overlooked on the post-mortem table, though clearly visible to the X-rays. Thus the following experience of L. G. Cole illustrates what may well be a common happening. "One specimen of a child's lung appeared normal on external examination, but the radiogram showed several distinct old calcified lesions. On careful cross section these were not found, and the lungs were reported normal by the pathologist. Fortunately the sections were saved, and when these spots were localised by sticking hat-pins in at different angles and making more radiograms, they were readily located, and when they were examined microscopically they were reported as being tuberculous."

It is, then, into a chest thus scarred with the marks of old disease that we must look when we search for the evidences of active tuberculosis, and it is this which makes the task so difficult and so uncertain in most cases of recent activity. For the presence of old disease must obviously be allowed for, and yet there can be no standard amount of disease at which we can fix the limits of normality. The healthy may show some more,

some less, without any consequent difference in their vigour and fitness. True, the question of activity of disease is the real criterion, but, unfortunately, it is on this very point that the X-rays are unable, in many cases, to furnish decisive evidence. Not infrequently, in cases of early quiet disease, or recrudescence, the radiologist will speak of shadowings, but can give no definite opinion as to their activity; to determine which point an appeal to symptoms has to be made, whereby, since these are seldom characteristic, the diagnosis is not notably advanced.

In practice we find that with X-rays, just as with physical signs, though to a less definite extent, cases of tuberculosis can be divided up into two main categories—hilus tuberculosis, and apical phthisis. We will here make some attempt to give them separate delineation from the radiographical point of view.

Hilus Tuberculosis

In the adult this clearly represents a recrudescence and onward spread of the original 'primary' tuberculosis of childhood or early life. Shadows of hilus and bronchial tree are heavy, and not very rarely a fresh enlargement of the lymphatic glands can be detected. It is characteristic of the condition that the spread is, for the most part, fanwise in all directions, and that both lungs are attacked, though disease is often of more active nature in one lung than in the other. Peribronchial disease of a chronic type, associated with much fibrous development, is the rule (see Fig. 16), but various degrees of activity may be detected between this and the comparatively uncommon broncho-pneumonic type of disease. The following represents a composite picture in brief of three fairly characteristic types.

1. **Chronic and quiet disease with little or no evidence of activity.** Root shadows heavy and dense, with here and there caseous or calcified gland shadows

within them. Strands upward and downward from the root appearing wide and tapelike but of sharp outline, the

Taken by Dr. G. Harrison Orton.

Fig. 16.—To illustrate Hilus Tuberculosis of chronic type.

lower more thickened and showing a clear, and perhaps a dilated, lumen (bronchiectasis). The lung reticulum strongly accentuated, with a general 'fibrous appearance.' This may appear to branch off from the root and

strands only a certain distance, perhaps half way, into the lung; more commonly the thickened network is seen to extend to the periphery. In either condition the spread of disease is fairly equal on the two sides. In some cases the disease may miss both apex and base, and assume a 'butterfly' appearance through the development of a central wedge in each lung. The general fibrous appearance may be present without any 'nodules,' and yet the case be tuberculous. More commonly small roundish nodules of sharp outline are visible here and there, in some cases isolated, but more commonly linked up in the thickened lung network. They may be so numerous as to fill the whole network like knots, and are then often fusiform on their way to fibrous obliteration.

2. **More active disease.** The root shadows are very heavy, and somewhat fluffy in outline. The upward and downward extensions from the root are thick and also of soft woolly outline; within the lower branches are visible the clear spaces of the bronchial lumen, here of natural size, there dilated and bronchiectatic, appearing as thick tubes, or as thick rings where seen in optical section. The upward strands are of fully $\frac{1}{2}$ cm. width on the plate, and of irregular, nodular, even 'budding' outline. At their extremity they tend to look broken up or nodular if disease is progressive. Further out in the lung the network is thickened irregularly, giving an appearance in many places of a ring with clear centre; nodular shadows of various size and not very sharp outline are linked up into the reticulum. No areas of broncho-pneumonia or dense consolidation appear.

3. **Active and acute disease.** The upward and downward strands and the lung network have vanished—or the upward strands are still visible with an appearance of 'breaking up.' The fields are filled, or partly filled, with patches like flecks of summer cloud,

of fluffy outline, and of varying size and density—here

Taken by Dr. G. Harrison Orton.

Fig. 17.—To illustrate Hilus Tuberculosis of acute type. In spite of the extensive deep disease no crepitations had yet appeared at the surface.

small, round, discrete and of little solidarity, there coalescing into larger and denser shadows but with the

same fleecy contour. At another part appear areas of complete consolidation, dense and homogeneous; where the shadows are confluent the ribs will appear obscured or even hidden. As in the more chronic cases, the distribution tends to be of similar amount and location in both lungs. It may involve the middle of each lung in a fan-shaped area, or may appear to be directed outwards in two or three directions from the root. In all varieties of the disease cavitation may show itself, and it is characteristic of hilus tuberculosis that cavities develop deep in the lung and just outside its root.

So much for the X-ray appearances in average types of hilus tuberculosis. The condition has generally been described by the radiologist under the heading of "peribronchial phthisis," and Walsham and Overend divide it into four varieties according to the amount and nature of the disease process. The common cases of chronic type and limited spread, with a tendency to fibrosis and recovery, are classed as "Peribronchitis tuberculosa simplex." Where there is extensive distribution of peribronchial tubercles throughout the lungs, the condition becomes "Peribronchitis tuberculosa disseminata." If there is a marked tendency to fibrosis, in individuals of good reactive powers, the term "Peribronchitis tuberculosa fibrosa" is used. Lastly, acute cases with rapid enlargement of the tuberculous nodules, and the appearance of broncho-pneumonic shadows are designated "Peribronchitis tuberculosa exsudativa."

Apical phthisis

Where disease is of this type it may reveal itself to the physician before any shadowing is visible to the radiologist, but in nearly all cases the latter is able to demonstrate, in these cases, a connecting link of disease between the apex and the root of the lung. This is not to affirm that disease has necessarily spread out

from the root; indeed there is evidence of a general nature to suggest that phthisis is, in contradistinction to hilus tuberculosis, a true fresh infection from outside

Taken by Dr. W. Overend and reproduced from the Archives of Radiology and Electrotherapy.

Fig. 18.—To illustrate double Apical Phthisis of chronic type.

—a super- or re-infection, instead of a recrudescence of older disease. It may well be that the visible lines of communication between apex and root represent a subsequent or simultaneous process, and no outward path of spread as might, at first sight, appear. Generally

the strands running upwards from the root become wide, thick, and nodular, and around them may appear scattered tubercles, or patches of broncho-pneumonia (see also p. 131). A cap of apical pleurisy may tend to obscure the intrapulmonary changes. In contrast to the 'primary' hilus tuberculosis of childhood, and its recrudescence in adults, no fresh enlargement of lymphatic glands accompanies apical phthisis—in this respect it follows the rule formulated by Koch for the discrimination of super- or re-infections in tuberculosis. Jordan found 20 per cent. of his cases strictly 'apical,' 40 per cent. 'peribronchial,' and the remaining 40 per cent. both apical and peribronchial to radiographic examination.

Routine of Examination

On the radiogram taken from a chest suspected of tuberculosis a definite scheme of examination should be followed out. There must be noted the appearance of the root shadow; the condition of the lung framework, both branches and twigs, built up by bronchi and blood-vessels, and their accompanying lymphatics; and, lastly, the aspect of the parenchyma of the lung. Examination for tracheo-bronchial shadowing must also not be omitted (p. 267). In apical phthisis it is generally for the appearance of fresh disease, first shown as a deposit of tubercles around the upward strands, that we search; in hilus tuberculosis our attention is concentrated, rather, on evidences of reactivity or spread among old tuberculous processes involving the central areas of the lungs.

1. The condition of **the hilus** of each lung must be noted in respect of (*a*) glands, (*b*) large bronchi and vessels, (*c*) lung parenchyma.

Diseased glands may be large and isolated or, more frequently, show as a group of glands connected by

fibrous tissue. They may be caseous or calcified in whole or in part; if large and of woolly outline disease in them is probably active. The large bronchi may show as thick circles, or figures of eight, from infiltration of their walls, and, if disease is active, they may be surrounded by isolated tubercles. An active parenchymatous infiltration may be present at or around the root, and cast a diffuse homogeneous shadow on the plate.

2. The **lung arborisation,** composed of bronchi, blood-vessels, and lymphatics, must be carefully studied, particularly in its main trunks upwards and downwards, with a view to abnormalities brought about by the development of tuberculous disease. Widening of these strands must be looked for, and this may amount, on the plate, to $\frac{1}{2}$ cm. in the main branches and $\frac{1}{4}$ cm. further into the lung. In addition the 'nodular' or 'budding' appearance of recrudescing disease may be present and must be duly noted. The descending bronchi may be filled with secretion and appear as solid strands; if their lumen is visible it should be noted whether this is of normal size, or whether they are dilated and bronchiectatic. Further out in the lung the network and arborisation may show increased density, or may become nodular from the development of tubercles, giving an appearance which has been likened to the budding of a tree in spring time. If disease assumes an acuter aspect the diseased strands and network break up and disappear, leaving the tuberculous foci isolated and disconnected.

3. The **lung parenchyma** may be clear of the shadows of disease, or may show isolated or conglomerate tubercles, or patches of broncho-pneumonic consolidation, or a more diffuse homogeneous infiltration.

It is the tubercle which presents the crucial test of tuberculosis, and it is for this that we must search before committing ourselves to a definite opinion upon

the nature of lung shadowings. "I am very cautious about making a diagnosis of tuberculosis," remarks Cole, "in those cases in which the typical tubercles are absent." Tubercles may be so small as to be just visible, or large and soft-looking, or, with a more chronic process, of clear-cut and sharply defined outline. They may appear isolated from the lung network, but where disease is of a quiet and healing type they may be clearly linked up with this as nodules on its framework, and may assume a fusiform shape on their road to fibrosis. Acute disease will show itself by the development of large and woolly shadows of lobular pneumonia with but little or no visibility of the lung arborisation (see also pp. 124 and 271).

It may be taken as a general rule in radiography that a woolly outline denotes an active process. But in this connection note must be made of the fallacy that structures which are out of focus tend to appear diffuse and woolly, and hence to simulate the hall marks of high activity. Many grades between the acute and chronic extremes will be recognisable.

With regard to distribution, tubercles may be found near one or both apices, in a single lobe, or scattered throughout one or both lungs. Especially should careful search for them be made in the area described by Schut as the "infraclavicular triangle." This is bounded by the clavicle above, the mediastinal shadow within, and below by an imaginary line drawn from the lung hilus to the shoulder; it is in this area rather than at the apex that, in most cases, the earliest tubercles become visible in the first stages of phthisis.

The apices of the lungs must be carefully searched, but not too much reliance should be placed on the result. The apex is difficult to see in an ordinary plate, and even in radiograms taken with this special purpose early exudative processes cannot be shown. Dunham of

Cincinnati describes a delicate network in early tubercle suggestive of vascular congestion. Adam, working with Albers-Schönberg on sanatorium cases, recorded many failures in diagnosis by apical investigation. Differences of shadowing on the two sides is common in normal chests; moreover, the occurrence of simple temporary collapse has to be reckoned with.

Most important is observation of the strands running from the hilus into the apex, for, according to Schut, it is round the innermost of these, which stereoscopy has shown to pass to the posterior part of the apex, that the earliest apical changes are found. Overend has divided these upward bronchi into paravertebral, midclavicular, and axillary. He finds the paravertebral or innermost branch to run parallel to the vertebral column, and terminate within the circle of the first rib, supplying the acini in its neighbourhood and most of the supraclavicular apex. The commonest aggregation of foci occurs, according to him, around this branch at or about the level of the osseous extremity of the first rib.

Further points. Other, conditions which the radiogram may reveal in cases investigated with a view to phthisis, are ossification of cartilages, and apparent diminution in the size of the heart. Ossification of the first-rib cartilages as an accompaniment of phthisis was first described by Freund in 1859; but Boardman and Dunham have clearly shown that its apparent connexion with phthisis is accidental only, and that its presence has no diagnostic or causative significance. The same observers seem to have disposed also of the reputed value of the cardio-thoracic index. They found that hearts in phthisis are no smaller than is normal to the corresponding age and sex. Achelis, working with the orthodiagraph, was able to go still further, and declared not only that the diminution in size was largely apparent, but that the heart in phthisis was in general

actually larger than that of normal people of the same size and weight. The vertical heart of chronic lung disease, Hickey's sign, probably produced by the tension of contracting fibrous tissue in the surrounding organs, is a phenomenon which is familiar to all who work with the X-rays.

No more than mention need here be made of retraction of an apex, cardiac displacement, sloping of ribs and narrowing of intercostal spaces (beware of scoliosis as a cause of this !), or pneumothorax—conditions readily shown by radiographic means, but not the evidences of early tubercular disease.

Especially valuable are the X-rays, as Jamin points out, in cases where tuberculosis is grafted on to chronic bronchitis with emphysema. Such cases, as Albrecht has recorded, are apt to appear on the post-mortem table undiagnosed. The over-extension of lung greatly obscures the physical signs of disease, and the large quantity of sputum may render the discovery of the tubercle bacillus negative—difficulties which a skiagram will quickly remove.

RADIOSCOPY

Though radiography furnishes the widest evidence with regard to the lung condition, we need the fluorescent screen for the observation of two points—inspiratory brightening of the apices, and diaphragmatic movements.

Apical brightening. A difference in clarity of the lung tissue occurs between expiration and inspiration, and a failure to brighten on the part of an apex during deep inspiration, or with cough, is one of the earliest X-ray signs of phthisis. For its observation G. H. Orton recommends that at least ten minutes darkness precede screening, to allow the retina to accommodate itself, that rays of low penetration be employed, and

that the area under examination be but faintly illuminated, the diaphragm of the tube being narrowed down to a mere slit. Unfortunately this failure to brighten is a fallacious test, and may depend on many other causes than phthisis (see p. 78).

Diaphragmatic movement. The importance of this investigation depends on the fact that diminution and lagging of movement are found in a proportion of early cases of phthisis. This phenomenon was first described in 1897 by Francis Williams of Boston, and is generally associated with his name. The fact is everywhere admitted, though its value as an early sign is now less esteemed than formerly. As a clue to adhesions it may be useful, and its occurrence is generally attributed at the present time to pleurisy: (*a*) pleurisy with adhesions; (*b*) diaphragmatic pleurisy, perhaps without adhesions; (*c*) apical pleurisy, causing damage to the phrenic nerve. Pottenger suggested that it was due to an association of the diaphragm with the neck muscles in the spasm, and subsequent degeneration, following 'segmental stimulation' in lung tuberculosis (see p. 46); the phrenic nerve is derived from the same segments of the cord (3rd and 4th, or 4th and 5th cervical), as are the neck muscles chiefly involved. De la Camp and Mohr found it in one-third of early cases, but only with evidence of an apical pleurisy. It is the equivalent, from the side of Röntgen rays, of Litten's shadow phenomenon and tidal percussion (see p. 73), from the side of ordinary physical examination.

Technique.

A word should be said at the conclusion as to the technical difficulties involved in X-ray diagnosis. The physician is to some extent at the mercy of the radiographer, even though he possesses considerable experience of the X-rays in disease. The technique is so special that he cannot usually presume to advise on it,

and must to some extent sink his judgment on such matters as hardness or softness of tube, length of exposure, distance between plate and tube, and the level at which the photograph is taken. He can, as a rule, merely indicate what points he wants to bring out, and leave the rest to the expert. He should, however, train himself to interpret the results, and to do so his plates must be produced, so far as possible, under the same conditions and hence, preferably, by the same operator. Certain technical points are worth a reminder nevertheless—the utility of a stereoscopic picture, first taught by Wenckebach; the superior value, in practice, of an anterior plate, but the importance of obtaining, wherever possible, both a dorso-ventral and ventro-dorsal exposure; the different power of penetration of rays from the tube according to its condition of 'hardness' or 'softness'; the effect of the development of the plate in retention or otherwise of the finer lines; the distortion caused by perspective and increased by reducing the distance between plate and tube. Time of exposure for chest work should be as near instantaneous as possible. The development in recent years of 'snap-shot' or instantaneous radiography has revolutionised results by providing us with details on the negative which no eye could ever detect on the fluorescent screen. On this account the radiogram has attained the position of first importance, and screening can never take its place in chest work. Already exposures of $\frac{1}{80}$ to $\frac{1}{200}$ second have been used, and further developments may before long render these available even for penetration of the adult chest.

TUBERCULIN

INTRODUCTION

The amount of space devoted to tuberculin in this volume will be found to correspond more nearly with the claims that have from time to time been made for it, than with its actual worth in diagnosis. It was the writer's original intention to deal but shortly with this subject, describing only such tests as he himself relies on, and ignoring those which accumulated knowledge has shown to be misleading or useless. Such exemplary reticence, excellent in theory, was soon found to be impossible in practice; for each tuberculin test is compounded of many elements, some of which are of value while others may be comparatively useless. One test is of definite account when positive, another only when it fails; a third discovers evidence whose value amounts to certainty, probability, or nullity according to circumstances, and all within the limits of the same experiment. No one method covers all the ground of diagnosis; few fail to disclose some element of possible value within suitable limitations.

Thus it appeared that the majority of the methods must claim some recognition, however slight, and the matter having got so far, it seemed best to proceed still further so as to include a statement of the reasons for and against each test, and a more or less comprehensive account of its application. This course, against which the writer for a time struggled, seemed to him to find justification in the very imperfect knowledge often displayed in this country in regard to the true value of these different tests. For, from time

to time, statements likely to mislead the uninitiated appear in medical journals extolling one or other test, and that without reference to the facts, necessarily of foreign compilation for the most part, on which such commendation is or should be based. If the busy practitioner is to keep his head among such opposing claims, it is necessary that he be furnished with the essential parts of the evidence by which the worth of each method may be tried.

At the outset he must know that the value of any particular tuberculin test is no longer a matter of opinion but one of ascertained fact. For an enormous mass of material, gathered from all quarters, is now to hand as a standard, the results of every form of test on every form of tuberculosis, and also on the healthy. Such material, when sifted, admits, in most cases, of but one interpretation. It is, therefore, no longer open to any individual to say, " I believe in this or that tuberculin test in diagnosis " unless his belief is supported by these uncontrovertible facts. Heterodoxy can only be evidence of ignorance or bias; for no question of skill comes in with diagnostic as with therapeutic tuberculin to cloud the issue. A milligram given subcutaneously produces the same effects in the hands of one observer as in those of another. We are dealing with facts and the collocation of facts. No one, to take a concrete example, can in these days rely on a positive von Pirquet reaction as evidence of active tuberculosis in the adult and retain our respect for his intelligence; a vast mountain of fact is against him.

Thus it appears that our attitude to the various tuberculin tests, when once the facts have been ascertained, is not a matter of choice but one of necessity. We must eliminate the useless and hold on to whatever can give us evidence of value. We must, moreover, sift again this evidence so as to acquaint ourselves with the relative worth of these tests, and determine what

amount of reliability they can provide for us. Out of this inquiry three truths will be found to emerge with more or less clearness; firstly, the value, above all other events, of a focal reaction; secondly, the worth of negative results to the subcutaneous and, to a less extent, to the cutaneous tests, in the exclusion of active disease; thirdly, the very much smaller value, only that of probabilities, more or less high, attaching to the determination of tuberculin sensitiveness, whether of skin or tissue, in diagnosis.

Tubercular infection and tubercular disease. Tuberculin is innocuous to the tubercle-free. Enormous doses can be given to new-born babies without any more effect than that caused locally by its glycerin content. Infection with the tubercle bacillus, however, renders the tissues sensitive to tuberculin, and this sensitiveness forms a convenient test of such infection. But sensitiveness may last a long time after disease is quiescent or cured, so that the mere presence of sensitiveness indicates only former infection, not present disease.

The distinction between tubercular infection and tubercular disease must be clearly understood. It is the latter only which interests the diagnostician. Nearly all adults living in a civilised community have been infected at one time or other, and the majority will react to the more delicate tuberculin tests. Indeed, it has been shown for many large towns that even so early as the tenth or eleventh year of life some 90 per cent. have already encountered the tubercle bacillus, as the chart on p. 223 well shows. This chart also shows the high mortality from tuberculosis during the first two or three years of life, a mortality nearly covering the incidence of infection. At this age tubercular infection and tubercular disease are nearly synonymous terms.

It thus happens that our requirements, *qua* the tuberculin tests. are for infancy quite different from those for

adults. For infants it is sufficient to show that infection with the tubercle bacillus has occurred, and for this purpose we use the most delicate tests we have, the cutaneous, the intracutaneous, or the 'stichreaktion' of Escherich. For adults, living in communities, these do not suffice. It does not interest us much to know that they have been infected sometime and somewhere. We require answers to the following questions—

(i) Is active disease present, or can it be excluded?
(ii) Where is the disease situated? or, looked at from another point of view, is the suspected area of disease caused by the tubercle bacillus?

The degree to which tuberculin can supply an answer to these questions will appear in more practical form under the various headings to follow.

The triple action of tuberculin. Tuberculin in the sensitive is capable of calling out a threefold action. The **local reaction** appears at the point of its application, whether to the abraded skin, to the mucous membrane, rubbed into the intact skin, or injected into or under it. The **general reaction,** with which is associated the **febrile reaction,** shows itself in general toxic symptoms of influenza-like character to injected tuberculin: as fever, headache, malaise, nausea, vomiting, chilliness, and the like. The **focal reaction** depends on a specific attraction of the toxin to the focus of disease in the body, giving rise to hyperæmia and symptoms and signs corresponding with this. It is obvious that tuberculin can be applied for diagnostic purposes in two main ways: to the tissues locally, or to the tissues generally by injection.

THE CUTANEOUS TEST (von Pirquet)

In this test old tuberculin, generally undiluted, is applied to the scarified skin and gives rise, in the tubercular-sensitive, to a well-defined papule. It is one of

the most delicate tests, and only answers for us the question "Has there been at some time infection with the tubercle bacillus?" On this account only a proportion of healthy adults fail to react, and the utility of the test is practically confined to infancy and early childhood, where infection is synonymous with disease. It will be described in this connexion at the latter end of this volume (p. 277), together with the intra- and percutaneous and the subcutaneous-local tests, all bearing a similar significance. In combination with the conjunctival test its use has been recommended in phthisis, and the application of this method will be considered under the heading of the conjunctival test (p. 155).

THE QUANTITATIVE CUTANEOUS TEST
(Quanti-Pirquet, qP, of Morland).

Though the ordinary cutaneous test possesses, by itself, no value for the diagnosis of phthisis in adults, there remains the possibility of measuring the amount of tuberculin sensitiveness by the use of graduated dilutions, and employing this knowledge for what it is worth in diagnosis (see pp. 148 to 150). White, Graham, and Norman have together worked out a method whereby the same quantity of different dilutions is instilled into the skin till a papule of a standard size is experimentally reached. By these means they are able to compare the sensitiveness of different cases of disease, and thus decide on a suitable dose with which to begin treatment. The method has therapeutic aims in view, and the more difficult and laborious technique and delayed results render it less suitable for diagnostic purposes than the method of Ellermann and Erlandsen about to be described.

Method of Ellermann and Erlandsen

To determine the skin sensitiveness of a patient to tuberculin it is required to find the weakest dilution to

which he will just react. This would be very troublesome or impossible to discover by direct experiment, especially since even skin reactions to some extent alter sensitiveness to subsequent tests (see writer's results, p. 149). Ellermann and Erlandsen surmounted this difficulty by the use of simultaneous inoculations with a series of dilutions of known strength, and an ingenious

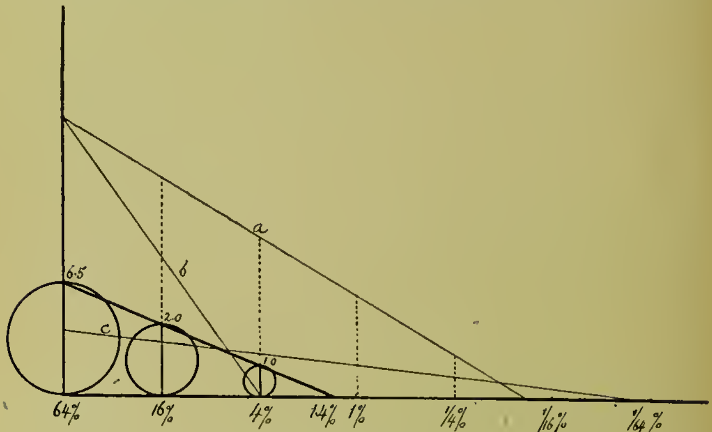


FIG. 19.—GRAPHIC DELINEATION OF ELLERMANN AND ERLANDSEN'S TEST AFTER MORLAND.

Tuberculin dilutions are placed along the base line, and uprights through them mark the diameter of the papules produced. Circles represent the papules developed in the case exemplified on p. 142; a line joining their diameters shows the reaction to vanish at a tuberculin dilution of 1·4 per cent. or about $\frac{1}{71}$, giving S = 71. The lines *a*, *b*, and *c* mark other possible combinations of papules and touch at the base line sensitiveness-figures of various amount.

calculation of the vanishing point of the reaction from measurement of the resulting papules. The method is based on the assumption, supported by numerous experiments with tuberculin and sanctioned by Weber's law, that where the strength of the stimulus (tuberculin) varies in geometric progression, the response (the papule) will vary in arithmetical progression.

Dilutions of strength rising in geometric series are applied simultaneously to the skin and the resulting papules measured and compared. By means of a formula, replaced for convenience by the use of a table (p. 143), there can be calculated from the papule size and the papule difference the dilution of tuberculin at which reaction vanishes, and the reciprocal of this is taken to represent the individual sensitiveness. Thus, for example, a patient reacting, at lowest, to 1 : 1,000 tuberculin is said to have a sensitiveness of 1,000; to 1 : 100 a sensitiveness of 100. The matter has been much simplified by Morland through the medium of graphic representation. In the accompanying diagram (Fig. 19) the various concentrations of tuberculin are marked at equal distances along a base line, from which perpendiculars are raised proportionate to the size of the papules; if the ends of these are joined by a line this will intersect the base line at the point where the reaction vanishes. It is this point which we desire to know, and this we can calculate from average papule size and average papule difference by means of the table supplied in the text.

Technique. Dilutions of old tuberculin are made up in 1 per cent., 4 per cent., 16 per cent., and 64 per cent. strength (see Fig. 19); that is in a convenient geometric series, the diluent being the usual normal saline solution containing 0·5 per cent. of phenol.

The front of the forearm is cleaned with ether and four holes drilled in a line with a von Pirquet scarifier, together with a fifth hole as a control, beside or below the lowest. The holes should be at least 1 inch apart, and must be just so deep that their bases are moist and vivid pink but do not bleed. This depth is only learned by practical experience, and varies much for different skins. The tuberculin dilutions are now applied to these scarifications in sequence, the 1 per cent.

below and the 64 per cent. above, and after two minutes the excess of fluid is removed with clean cotton wool and the remainder allowed to dry in.

After twenty-four hours, and again after forty-eight hours, the arm is examined and the diameter of the resulting papules measured with callipers and rule. In doing this it will be found that a very considerable 'traumatic reaction' results from the use of the von Pirquet scarifier, the amount of this, often a papule of 3 or 4 mm. diameter, being indicated by the control scarification to which no tuberculin was applied. This amount is subtracted, as irrelevant, from the diameter of each other papule, and the results are recorded in a book. Thus we obtain four figures for each day of measurement, and something of the result will be at once apparent. For, reaction may fail to the 1 per cent. dilution, when we know that sensitiveness will be below 100; it may be absent to both 1 per cent. and 4 per cent., when sensitiveness will be below $\frac{100}{4}$, or 25; it may fail to 1 per cent., 4 per cent., 16 per cent., when sensitiveness will be below $\frac{100}{16} = 6$; or it may fail to all dilutions, when sensitiveness is below $\frac{100}{64}$ or $1\frac{1}{4}$. The more exact equivalent in any case is worked out from the average papule size and average papule difference applied to the table exhibited on the opposite page. To take an example—

Dilutions.	13. VI. 1913.	14. VI. 1913.	Average.	Difference.
64 %	5·5	6·5	6	
				3·5
16 %	3	2	2·5	
				1·0
4 %	2	1	1·5	
				1·5
1 %	0	0	0	3)6
			4)10·0	D = 2
			P = 2·5	

Papule size.	Papule difference.																			
mm.	5	4¾	4½	4¼	4	3¾	3½	3¼	3	2¾	2½	2¼	2	1¾	1½	1¼	1	¾	½	¼
8	115	129	147	170	200	240	298	379	504	706	1056									
7½	100	111	125	144	168	200	243	307	400	546	800	1270								
7	87	96	108	122	141	166	200	247	317	426	607	935	1603							
6½	76	84	92	104	119	138	164	200	252	331	460	687	1132							
6	66	72	79	88	100	115	134	161	200	257	348	503	800	1451						
5½	57	62	68	75	84	95	110	130	157	200	263	370	566	974	2018					
5	50	54	58	64	71	79	90	105	126	156	200	272	400	657	1270					
4½	44	46	50	54	60	66	74	85	100	121	151	200	283	441	800	1840				
4	38	40	43	46	50	55	61	67	79	94	115	147	200	298	504	1056				
3½	33	35	37	39	42	45	50	56	63	73	87	108	141	200	317	707	1603			
3	29	30	31	33	35	38	41	45	50	56	66	80	100	134	200	348	800	3200		
2½	25	26	27	28	30	31	33	36	39	44	50	58	71	90	126	200	400	1270		
2	22	22	23	24	25	26	27	29	31	34	38	43	50	61	79	115	200	504	3200	
1½	19	19	20	20	21	22	22	24	25	27	28	31	35	41	50	66	100	200	800	
1	16	16	16	16	17	17	18	19	20	21	22	23	25	27	31	38	50	79	200	3200
½	14	14	14	14	15	15	15	15	15	15	16	16	17	18	20	22	25	31	50	200

ERLANDSEN'S TABLE SIMPLIFIED BY MORLAND.

Here we find that the average papule size P = 2·5 and the average papule difference D = 2, and on reference to the table it is shown that the sensitiveness S = 71. This was a case of phthisis in the first stage and in good general condition.

Fallacies of the method and how they are met. The development of the tuberculin papule is dependent on many factors, some of which are yet but imperfectly understood. Von Pirquet himself admits that variations below 50 per cent. in the diameter of the papule may be due to unavoidable differences in technique. The most far-reaching work on these lines is that of Schutz and Videky, and some of their results are worthy of brief record here. They found the **time of maximum development** of the papule varied over many days. Thus it was reached on the

1st day in 104 cases,
2nd day in 139 cases,
3rd day in 25 cases,
4th day in 15 cases, etc.

among their material; delay is especially likely to occur, according to Kögel, with the weaker dilutions. This difficulty is met in the Ellermann and Erlandsen method by taking the average over the first and second, that is the two most important days. Schutz and Videky, and also Sachs, have shown that great differences in papule development occur according to the **locality of the area of skin** tested; thus the back grows papules of much greater size than the forearm. This fact adds no fallacy to the Quanti-Pirquet method, since the front of the forearm is alone used. Greater, however, than all other fallacies are those which may arise from **differences in absorption** of the tuberculin applied. White and Graham insist on the need of applying a definite dose to the skin, and this view is upheld by Sachs; but Boardman (quoted by Hamman

and Wolman) was able to show that the quantity was of so insignificant importance compared to the concentration as to be negligible. The effect of length of application is a more important matter. Schutz and Videky obtained enormous differences according to whether the tuberculin solution was left to dry on the skin or quickly wiped away. Thus—

Dried on skin, 80–63 sq. mm. of papule developed.
Half-dried before removal, 25–30 sq. mm. of papule developed.
Wiped off early, 6–42 sq. mm. of papule developed.

Boardman, on the other hand, showed that but little further absorption occurred after ten minutes application. It appears to the writer also that the greater glycerin content in the stronger dilutions may exercise an important influence on absorption by ensuring closer contact with the skin and delaying evaporation. A certain amount of difference in absorption also occurs, but much less than might be expected, according to the depth of the scarification made with the von Pirquet instrument. The writer found differences of only about 0·5 mm. between very light and very deep scarifications in individuals tested on this point.

On account of the possible sources of error enumerated above, it is necessary that the utmost care be directed to the attainment of strict uniformity in all the technical details. Even with the most scrupulous care, unexplained discrepancies will arise in a certain proportion of cases. Thus Schutz and Videky, using dilutions of various strength, found that the expected difference in size of papule did not always appear. Thus—

To 25	per cent.	dilution	papule	= 48 sq. mm.	
5	,,	,,	,,	= 52 ,,	
25	,,	,,	,,	= 21 ,,	
5	,,	,,	,,	= 38 ,,	etc.

Sachs obtained similar discrepancies.

Kögel complains of finding papules 7 and 11 mm. diameter to the same dilution, and fails to confirm the experience of Ellermann and Erlandsen that the papules show an arithmetical increase to a geometrical rise in tuberculin concentration. Though the writer has found that, on occasion, the usual gradation of papules fails, and a larger papule appears to a weaker solution, yet this has been of quite exceptional occurrence among his cases; nevertheless he must agree that a true arithmetical sequence is but seldom obtained.

Reaction or no reaction. This, when the method is carried out with only four scarifications as is generally recommended, is often a matter very difficult to decide with regard to the lowest dilution. The writer has found that by the use of a fifth scarification, recommended above as a control, not only can this difficulty be removed but also the large error arising from traumatic œdema be measured and allowed for.

Multipapillary Cutaneous Method (M.P.C.) of Ellis

H. A. Ellis has introduced a method of measuring tuberculin sensitiveness which differs in some particulars from that of Ellermann and Erlandsen described above. He uses six dilutions—P.T.O. (I) as a bovine test, and dilutions of old tuberculin, T, 1 in 10 (II), 1 in 100 (III), 1 in 500 (IV), 1 in 1,000 (V), and 1 in 10,000 (VI). Simultaneous scarifications are made on the forearm through drops of these solutions, six to nine contiguous scratches over an area of 1 mm. diameter being made, each puncture deep enough to reach the vascular or papillary layer of the skin. Over these scarifications a layer of cotton-wool is strapped, and the reactions are observed, and compared as to their general characters, colour, elevation, size, etc., after 48 hours. The results are classified under four headings.

Hypersensitives. Those reacting markedly to 1 in 500 (IV) or over.

Sensitives. Responding definitely to 1 in 100 (III), this being the ' normal ' reaction in phthisis.

Subsensitives. Those with sensitiveness below 100, *i. e.* reacting to I and II.

Insensitives. Those which react but slightly or not at all to the strongest solution.

Relation of Skin and Tissue Sensitiveness

The diagnostic value attaching to the quantitative cutaneous test depends, of course, on how far the amount of tubercular sensitiveness is an indication of activity of disease. Since the same identical consideration arises in respect of the general reaction to subcutaneous tuberculin, it might seem rational to discuss the point once and for all for both these methods together. This would be done if it could be shown, as theoretical considerations would render probable, that skin and tissue sensitiveness are one and the same thing. Unfortunately, in practice it does not seem that the cutaneous and subcutaneous reactions altogether correspond, and it becomes necessary, at the present stage of our knowledge, to consider their practical application under separate headings (see also p. 165).

White, Graham, and van Norman claim to find a close correspondence between skin and tissue sensitiveness, and on the strength of a skin reaction to predict the dose at which a general reaction will occur. Such quantitative relationship has been but little tested : in the few cases where the writer has been able to compare skin sensitiveness on Ellermann and Erlandsen's lines with sensitiveness to subcutaneous tuberculin he has failed to verify any close relationship. A qualitative agreement, that is mere ' positive or negative ' unison, has been more often sought, and that without establish-

ing any very close correspondence in the hands of most observers. Hamilton, Carpenter, and Cope, however, found complete agreement between cutaneous, percutaneous, conjunctival, and subcutaneous tests in seventy-seven of eighty-three cases tested; Gordon also showed very sound accord between cutaneous and subcutaneous tests in eighty-four cases compared. These appear to be rather exceptionally favourable results. Lack of correspondence may depend partly on the fact that few or none of these qualitative reactions are strictly comparable in that a very different degree of sensitiveness is required to call them out.

The Significance of Skin Sensitiveness

With the skin, as with the tissues generally, we find that, on the whole, high tuberculin sensitiveness and active disease run together. Erlandsen and Petersen, from observations on 547 patients placed in three clinical groups—non-tubercular, suspected, and definitely tubercular—found the average sensitiveness increase as the groups are ascended. They put the dividing line between health and clinical tubercle at 100, and claimed that most cases of quiescent disease fall below this figure and that, vice versa, cases of active disease generally possess a sensitiveness higher than this. Morland finds values above 100 suggestive of active disease, and values below fifty of latent or arrested disease. The writer is in agreement with this so far as the upper limit is concerned. For the inferior limit he would substitute a somewhat lower figure, perhaps forty, since otherwise a large proportion of his cases of definite phthisis would fail to surmount it.

Its value in diagnosis. Unfortunately, when the test comes to be considered from the point of view of diagnosis we find, just as will be demonstrated for general tissue sensitiveness (p. 165), that a number

of exceptions break the rule on both sides of the line. Thus Hamman and Wolman found no less than 16 per cent. of the clinically non-tubercular gave a positive reaction to 1 per cent. tuberculin, or in other words possessed a sensitiveness of 100 or over. On the other hand, among cases of incipient phthisis, where above all we need the use of special diagnostic methods, 44 per cent. were negative to 1 per cent. tuberculin, and thus had a sensitiveness below 100; and, more serious still, 22 per cent. were negative to 5 per cent. tuberculin, or in other words had a sensitiveness below 20.

The writer's experience with Ellermann and Erlandsen's methods is well brought out by the figures of the last forty-five cases tested with the assistance of Dr. C. D. S. Aggassiz.

	Cases.	Sensitiveness above 40.	Sensitiveness 100 or over.	Sensitiveness below 40.	Negative reactions.
Phthisis :					
Tubercle bacilli present .	9	8	3	1	0
Clinical Phthisis :					
Tubercle bacilli absent .	14	9	3	5	3
Doubtfuls . . .	8	3	2	5	1
Non-tubercular . .	14	0	0	14	4
	45				

Among the cases of phthisis all were fairly early and all with good general nutrition; the case with tubercle bacilli in the sputum, but low sensitiveness, appeared to be clinically a case of enlarged tracheo-bronchial glands, and had stethoscopic signs suggestive of bronchitis only. It will be noted that the clinically non-tubercular failed, without exception, to show a sensitiveness as high as forty—nearly all reacted to the 64 per cent. dilution only. Eleven of the cases, indiscriminately selected, were tested a second time after an interval of three weeks, with the result that in eight cases sensitive-

ness had risen, in one it had fallen, and two cases already negative remained so.

Conclusions. The conclusions which the results of the quantitative cutaneous test seem to force upon us are as follows :—

(*a*) A sensitiveness running into 200 or 300 is strong evidence of active disease; sensitiveness of 100 is also evidence, but less strong, since, according to some investigators, a certain percentage of healthy people show a sensitiveness as high as this.

(*b*) Absence of reaction, or a sensitiveness below six, that is, so low that no reaction appears to the 16 per cent. tuberculin, is, apart from other explanation (see below), suggestive of absent or obsolete tubercle. Since, however, 22 per cent. of Hamman and Wolman's cases of incipient phthisis showed a sensitiveness below twenty (and the writer's figures uphold this discrepancy), the value of low sensitiveness must be interpreted with reserve. Two factors are concerned in the production of sensitiveness, a sufficient call on the defensive mechanism, and the power of active response. It is hardly surprising if, in the presence of definite disease, one or other of these factors be at times insufficient. The failure of the second under such conditions as advanced disease, malnutrition, acute fevers, and the like, must be, of course, expected and discounted.

It will be seen, then, from what has been written above, that we are dealing in this test with probabilities of a certain value, and as such only are they admissible as evidence for or against tuberculosis. They are links in the chain, but no more.

CONJUNCTIVAL TEST

The conjunctival test has fallen somewhat into disuse in this country, and, to a less extent, elsewhere, partly because its value seemed open to question, but mainly

on account of exaggerated fears with regard to its dangers. The writer holds no brief for the method and never employs it himself at the present time, but this is not on account of any dangers belonging to it, for, as a matter of fact, its risks are very small and, if 1 per cent. old tuberculin is used, quite negligible. Even with the stronger precipitated tuberculin serious results but rarely arise. Calmette among 6,303 tests encountered three cases of phlyctenular conjunctivitis, 20 of conjunctivitis, and 72 prolonged reactions. Hamman and Wolman among several thousand instillations saw but two untoward results, both of which recovered. Sachs in 500 cases found prolonged violent reaction in two, without any permanent injury to the eye. To be sure, de Lapersonne and Collin were able to show many cases of severe conjunctivitis leading to ulceration, but, as Schultz-Zehden pointed out, these belonged to the use of Calmette's special preparation and do not occur with the weaker 1 per cent. old tuberculin.

Precautions. If no stronger solution than this 1 per cent. old tuberculin is used for the first instillation, and other needful precautions observed, the conjunctival test may still be used with confidence. The further precautions advised consist mainly in the exclusion of all cases of present or former eye disease and the avoidance of reinstillation in the same eye. It is probably wiser, also, to exclude scrofulous children, who are subject to violent reactions, and also the aged, where impaired vitality makes corneal ulceration more conceivable. The conjunctival test has also serious drawbacks in cases where tuberculin is likely to be given subsequently by injection. Under such circumstances a secondary flare-up in the eye occurs in a proportion of cases, and that even to doses below the reaction level. This is likely to occur to diagnostic tuberculin where the doses are planned to be shocks, as it were, to the

protective mechanism, but is seen less commonly as a result of therapeutic inoculation.

Indications for its use. As to the value of the conjunctival test, this will be presently discussed; it may, however, be at once pointed out that its rôle in phthisis must be to take the place of the subcutaneous test where this is contra-indicated. Thus when fever is present, a not uncommon occurrence, subcutaneous injection, the tuberculin test *par excellence* in phthisis, cannot be given. There remains, then, the quantitative cutaneous test from which some information on the subject of sensitiveness may be obtained. Not all, however, are trained to the use of this test, and such may fall back on the cutaneous and conjunctival reactions used together in the manner to be presently described.

History. The idea of using the conjunctiva for a tuberculin test occurred to Wolff-Eisner, who described the method on May 15, 1907, at a meeting of the Berlin Medical Society. He used a solution of 10 per cent. strength, but this was modified by Calmette, who applied the test with a 1 per cent. dilution of tuberculin, precipitated from Koch's old tuberculin with alcohol. Solutions of precipitated tuberculin are some ten times stronger than the corresponding dilution of old tuberculin, and Comby soon introduced a $\frac{1}{2}$ per cent. strength to avoid severe reactions. Subsequently it was shown by MacLellan, and by Krause and Hertel, that the glycerine contained in old tuberculin does not, in weak dilutions, cause any conjunctival irritation, and it is now customary and convenient to apply the test with 1 per cent. old tuberculin in normal saline solution containing 0·5 per cent. of phenol.

Technique. The technique is simple. After carefully excluding all evidence of disease in the eye or eyelid, a drop of the solution is placed with an eye-

dropper at the inner end of the gently everted lower lid and allowed to flow round the eye. If there is abundant lachrymation, as in crying children, the test becomes unreliable. Twenty-four hours later the eye is examined and compared with the opposite eye. Three degrees of inflammatory reaction have been described, but the distinction is of no clinical value, and it is sufficient for our purpose if the question " positive " or " negative " is answered. In the presence of a negative result the test may be repeated with a stronger solution (4 to 5 per cent.) in the opposite eye a few days later.

Results

The results obtained with the conjunctival test present a very striking contrast to those of the cutaneous method. Whereas the latter is like a very fine net whose haul is so comprehensive that most of the apparently healthy come in, the conjunctival test presents an open mesh which lets through the healthy but loses also a certain proportion of cases truly tubercular.

Non-tubercular. Among the clinically non-tubercular but a small percentage react; thus Calmette, presumably using the strong 1 per cent. precipitated tuberculin, found 16·8 per cent. positive among 2,328 healthy persons. Smithies and Walker record 9·9 per cent. reactions among 1,379 cases collected from the German literature, and 6·8 per cent. among 205 cases tested by themselves with 1 per cent. precipitated tuberculin. Hamman and Wolman found only 2 per cent. react to 1 per cent. old tuberculin, and 6 per cent. to 5 per cent. dilution among 251 cases tested; Cohn in 188 cases got 5·3 per cent. reactions. Analogous results were obtained in other investigations, though they are not all strictly comparable owing to the differences in the tuberculin solution applied. We see, then, that the

test is discriminating, in that it excludes for the most part cases where disease is cured or obsolete.

Tubercular. When we apply the test to tuberculous material we obtain a much less satisfactory result. Smithies and Walker in a review of the literature found that cases in all stages of disease gave 93 per cent. positive among French (14,800 cases), and 86 per cent. among German investigators (1,554 cases). Calmette himself got 92 per cent. among 2,894 cases.

We find, then, that a very satisfactory percentage of tubercular cases in all stages react. When, however, we come to separate consideration of **incipient phthisis,** by which indeed the value of the test must stand or fall, we obtain much less conclusive results. For among these it becomes evident that the test fails in an important proportion of cases, so that a negative result can, by itself, give us no certain information. Baldwin, using $\frac{1}{3}$ and $\frac{1}{2}$ per cent. dilutions of precipitated tuberculin, obtained 28·6 per cent., and Sachs, with 1 per cent. old tuberculin, 33 per cent. negative results in incipient cases. Wolff-Eisner found 25 per cent. negative in Stage I of the disease, and Hamman and Wolman found 40 per cent. negative to 1 per cent., and 27 per cent. to 5 per cent. tuberculin among similar material. Bandelier and Röpke record the fact that the conjunctival test is positive (even after repetition) in only about half the cases of active early tuberculosis.

Conclusions. The following are the conclusions to which the results obtained by the conjunctival test must inevitably lead us :—

A positive result is of some value as evidence of active disease, since a comparatively small number of healthy adults react.

A negative result in no way excludes the presence of active disease, since a large proportion of failures appear among undoubted cases of incipient phthisis.

Combined Conjunctival and Cutaneous Test

Hamman and Wolman point out that the result described above is the direct opposite to that obtained by the cutaneous test with undiluted tuberculin, where a negative result is alone of value in adults.

The value of a negative cutaneous test will, of course, depend on the certainty of this test among the tubercular. Hamman and Wolman find it rarely to fail among cases with tubercle bacilli in the sputum; among cases of incipient phthisis they find it positive in 94 per cent. Sachs, on the other hand, only obtains it in 69 per cent. of incipient cases. Among mixed tubercular material Bandelier and Röpke obtain 2 to 4 per cent. failures, but Lossen 12 per cent. and Schutz and Videky 25 per cent. Thus it appears that with a negative cutaneous test a certain proportion of truly tuberculous cases will be missed, though the number is notably fewer than with a negative conjunctival reaction.

They suggest, therefore, that these **two tests should be used in conjunction** and simultaneously. By this means the weaker element of each is supported by the stronger element of the other.

Thus a **positive reaction to both tests** is evidence of the presence of an active tubercular focus in the body.

A **negative reaction to both tests** is evidence of the absence of active tuberculosis.

If the two do not correspond, and this discrepancy must of course be expected in a large number of cases, the experiment has proved valueless and no attention should be paid to it.

This use of the conjunctival test seems to the writer the only sensible one, and such a combined method may be worthy of application in some cases where the

subcutaneous test is ruled out on account of fever. It must be borne in mind, however, that even the double positive or the double negative in no way supplies a definite proof. Our patient may be among those 5–15 per cent. of healthy people who yet react to the conjunctival test; or among those 2·4–25 per cent. of adults with active tubercle who fail to cutaneous tuberculin. As with so many of these special tests, we are only dealing with probabilities more or less strong, and these may combine to deceive us. The results obtained, therefore, must only be regarded as links in the chain of evidence, and interpreted in due relationship to information derived from many other quarters.

THE SUBCUTANEOUS TUBERCULIN TEST

Old tuberculin has always been used for the subcutaneous test, and answers the purpose well. It is now, however, being largely replaced by the albumose-free preparation, **T.A.F.**, which is standardised to the same strength.

Dosage. The dosage of old tuberculin for diagnostic purposes has generally been expressed in terms of the milligram, **meaning thereby the cubic millimetre (c.mm.)**, which will here be substituted for it. It is the thousandth part of a cubic centimetre (c.c.), into which measure doses can be readily transposed by the addition of three places of decimals, thus : 0·1 c.mm. = 0·0001 c.c.

Koch's original dose of old tuberculin for diagnostic purposes was 1–5–10–10 c.mm., with intervals of a couple of days between. A variety of series is used at the present time, and the most notable change has been the nearly universal lowering of the initial dose.

Some examples of the dosage used by various clinicians

for the diagnosis of tubercle may here be given with advantage :—

Koch and Beck . . .	1–5–10–10 c.mm.
Cornet	1–3–5–6 c.mm.
Turban	0·5–2–5 c.mm.
Lawrason Brown . .	0·5–1–3–5–8 c.mm.
Pickert	0·5–0·5–0·75 c.mm.
Bandelier (1904) . .	1–5–10–10 c.mm.
Röpke (1908) . . .	0·2–1–5 c.mm.
Bandelier and Röpke (1913)	0·2–1–5–10 c.mm.
Löwenstein and Kauffmann	0·2 at three-day intervals
for four doses, and afterwards	2–5–10 c.mm.
M. Wolff	0·1–0·5–1–2–5–10 c.mm.
Petruschky . . .	0·1–0·5–2–5 c.mm. (children).

It must be borne in mind that dosage is designed to serve a definite purpose. We should begin low so that a high sensitiveness may be discovered, and also to avoid unpleasantly strong reactions; we must end high so that failure to react may be a fair guarantee that active disease is not present. **A convenient and safe dosage to follow is the series 0·2–1–5–10 c.mm.**, and half this dosage, namely **0·1–0·5–2·5–5 may be suitably used for children.**

Interval. Since reaction may in rare cases be delayed as long as thirty-eight hours after injection (Junker), an interval sufficient to cover this, the longest latent period, must be allowed. This will permit re-injection on the second day (*i. e.* in forty-eight hours), and this is convenient, though the third day is preferred by some.

Time of injection. The time of injection must be so arranged that a slight reaction shall not be passed over in sleep. This is only ensured by injecting in the early morning—in which case the reaction usually appears within six or eight hours; or late at night—when the reaction is nearly always delayed till the next morning,

for Hollmann has shown that the reaction comes four to eight hours later when injection is given at night and followed by sleep than when given at the beginning of the day.

Place of injection. This may be the arm, the back, or the flank. The arm is convenient, but has the disadvantage that it is most sensitive to subcutaneous local reactions, and these are of no diagnostic value in adults. The injection should be given at some point where the integuments are loose, and where friction and pressure are most easily avoided in case of painful reaction.

Technique. For those who are accustomed to the therapeutic use of tuberculin the preparation of dilutions is simplicity itself. Dilutions are made in series, each one-tenth the strength of the next, and are labelled Dil. 1, 2, 3, 4, and so on. To make these dilutions a 1 c.c. syringe is used, with a fine bore and thus a long scale—at least 4 cm. and better 5 or 6 cm. long—and graduated in one-tenths, here spoken of as **divisions.**

Now 1 c.c. of fluid is the equivalent of 1,000 c.mm. (formerly called mg.); therefore—

Dil. 1 contains 100 c.mm. of old tuberculin in every c.c.
Dil. 2 contains **10 c.mm.** in every c.c., and **5 c.mm.** in five divisions.
Dil. 3 contains **1 c.mm.** in every c.c., or **0.2 c.mm.** in two divisions.

Thus we find that Dils. 2 and 3 contain all the doses, here put in heavier type, needed for diagnostic purposes, and these can be made up in the usual way with normal saline solution containing 0·5 per cent. phenol, as follows :—

Dil. 2 from 1 c.c. of Dil. 1, or one division of original solution, and making up to 10 c.c. with diluent.

Dil. 3 from 1 c.c. of Dil. 2, and making up to 10 c.c.

with diluent (for further particulars, see Riviere and Morland, *Tuberculin Treatment*, or similar text-book). Dil. 3 will retain its potency many weeks, and Dil. 2 for some months (Bandelier and Röpke) if kept in a cool and dark place.

The skin is cleaned with ether, the dose sucked into the syringe and injected subcutaneously. Injection into a vein must be avoided, since a fivefold effect results; the appearance of a bleb under the skin during injection provides assurance that this is not taking place. No dressing is needed at the site of injection.

Observation and control. A three- or four-hourly temperature chart must be kept for two or three days previous to the test. After the injection the temperature should be taken every two hours while the patient is awake. A four-hourly observation is not sufficient to exclude slight and temporary rises. If a slight reaction is overlooked a larger dose might be given with undesirably violent results. This is the point above all others where caution is urgently needed. In the writer's experience neglect of a slight rise and the injection of a larger dose has been responsible for dangerous focal reactions.

Contra-indications

1. **Fever,** the presence of which renders the result unreliable and the test dangerous (see p. 170). Koch wrote: "Patients with temperatures over 37° C. (98·6° F.) (axillary) are unsuitable for the diagnostic administration of tuberculin, and should under no circumstances be submitted to the tuberculin test." If this rule had been more rigidly observed few, if any, of the accidents recorded in the literature would have occurred. A careful three- or four-hourly record must be kept for some days before the injection, which should be abandoned if the temperature rises above 99·2° F. in

the mouth or 99·8° F. in the rectum. It is obvious that the utility of the subcutaneous test is greatly limited by the need of excluding febrile patients.

2. **Obvious phthisis**, and especially cases where a secondary infection may be present. Under these circumstances the test becomes both needless and dangerous.

3. Recent hæmoptysis; suspicion of miliary tubercle; recent severe illness; serious diseases like diabetes in the young; advanced arterio-sclerosis; kidney disease; myocarditis, and also epilepsy.

General and Febrile Reaction

A rise of at least 1° F., or marked symptoms accompanying a somewhat smaller rise (as 0·7° F., mentioned by Pickert), is required to indicate a positive result. If a smaller or doubtful rise occurs the same dose must be repeated, never a larger one given. With repetition of the same dose the second result will probably be more marked, as the tissues are sensitised by the former one. Some common types of febrile reaction are illustrated in Figs. 20, 21, and 22.

Fallacies. A rise of temperature may not indicate a reaction but may occur from other causes, and for this reason the test must be interpreted with caution, especially in those with mobile temperatures—the young, the hysterical, and the neurotic. Occasionally a slight rise of temperature without symptoms occurs but fails to repeat itself to subsequent injection, and such an occurrence must be interpreted in a negative sense. In addition, the 'psychogenic' reaction, equally active to an *injectio vacua*, must be kept in mind. The local reaction may be used as a guide to doubtful reactions, since a general reaction rarely or never occurs without a local reaction to this or a previous dose.

Its value. It must be thoroughly realised that there

is no limit of dosage separating active from obsolete disease. The most that can be maintained is that, as a rule, fresh and active disease responds with a prompt and sharp reaction to a small dose, and that inactive and chronic processes tend to give a protracted reaction, and that only to higher dosage (see Amount of Sensitiveness, p. 165). But the exceptions to this generalisation are so notable that a febrile reaction can, by itself, tell us of no more than doubtful probabilities. It is, perhaps, best to consider separately the value to be attached to negative and positive results.

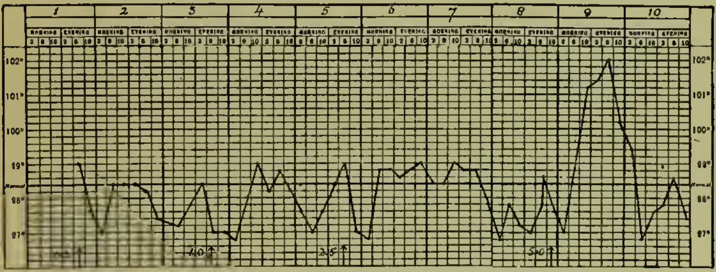


FIG. 20.—Types of Febrile Reaction to Diagnostic Tuberculin: Ordinary Sharp and Short Reaction.

A negative result when obtained is of great value in cases where absence of tubercular disease is the only likely interpretation. It must be borne in mind, however, that the test depends on tissue response, and that this must be expected to fail in conditions of acute illness, in the moribund, and in advanced phthisis. As Hamman and Wolman tersely put it, failure to react proclaims one of three conditions—freedom from tubercular disease, a healed focus, or a body overwhelmed with infection. In addition, a tubercular patient may be 'tolerant' of tuberculin either as a result of tuberculin treatment (even after years) or in some cases of successful autoinoculation. It is, however, in cases of early and

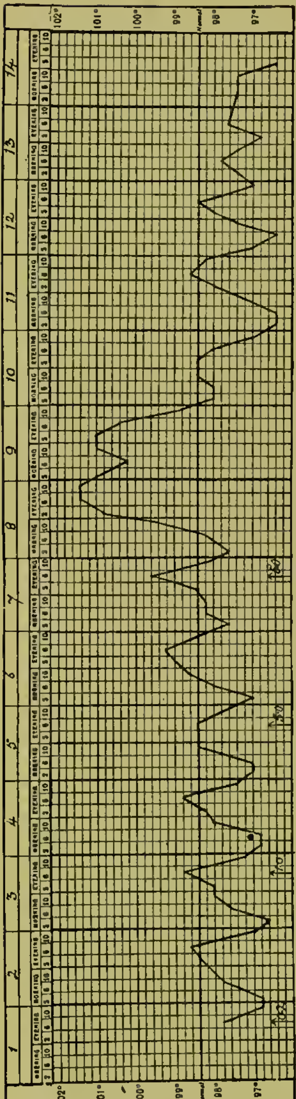


FIG. 21.—Types of Febrile Reaction to Diagnostic Tuberculin : Sluggish Reaction.

slight disease that the tuberculin test is required, **and in these a negative result furnishes strong evidence against the presence of active disease.**

There is general agreement on the value of a negative subcutaneous test in suspected early or slight disease. This is upheld by veterinary experience, and is established in human tuberculosis by numberless cases in the hands of numberless observers. Hamman was able by this means to send home 7·4 per cent. of his sanatorium cases, and Bandelier and Röpke, among similar material, obtained negative results in 5–10 per cent. If no further result accrued from the use of subcutaneous tuberculin, this alone would recommend its use. In advanced phthisis failures are to be expected, and the administration of diagnostic tuberculin to such is nothing short of malpraxis.

A positive result. Of less value and far more open to other interpretation is a positive result to the subcutaneous test. If the patient reacts promptly to the first small dose sensitive-

ness is high and some evidence in favour of active disease does, indeed, exist (see p. 165). For subsequent doses, however, it must be borne in mind that each tends to raise further the sensitiveness of the tissues to tuberculin, so that obsolete or inactive, as well as active disease, may give a positive response. In active cases, moreover, the result may be delayed to the final dose, so that neither does a positive result prove activity of disease, nor a failure to react to the smaller doses exclude the presence of this.

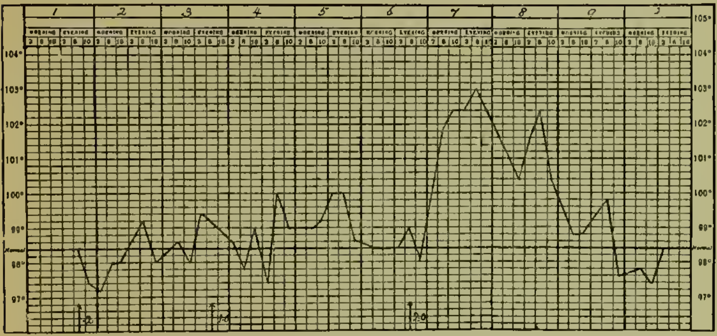


FIG. 22.—Types of Febrile Reaction to Diagnostic Tuberculin : Secondary Reaction, or Fall by Lysis.

So much misconception exists as to the value of a febrile (and general) reaction to subcutaneous tuberculin that the matter calls for fuller notice here. That a reaction denotes tuberculin infection is not disputed; the difficulty focuses round the question whether, and if so how far, it decides the activity of the disease whose presence it indicates.

Reactions without disease. That reactions occur in the clinically tubercle-free there is abundant evidence to show. Karl Franz, testing 400 Bosnian soldiers stationed at Vienna, found that 61 per cent. reacted on arrival, and after a year's sojourn in the city no less than 76 per cent. reacted. Another batch of 321 showed 222 positive reactions (68·8 per cent.), 84 to 1 mg.,

34 to 2 mg., and 104 to 3 mg. Among 1,002 soldiers altogether followed up only 64 developed clinical tubercle within six to seven years, and of these 46 had been positive and 18 negative when tested. Binswanger, testing 78 healthy nurses, found 33·3 per cent. react to a dosage of 1, 3, 5, 10 mg. Beck, working in Koch's Institute, had experience of 2,508 cases tested with subcutaneous tuberculin. These included all varieties of disease, and the following are some of the results obtained.

	Cases.	Per cent. of Positive Reactions.
Gonorrhœa	106	55·6
Erysipelas	96	54·2
Gynæcological cases	87	50·6
Joint Rheumatism	82	56·1
Muscular Rheumatism	31	74·0
Convalescent Typhoid	58	46·5

Among the whole of his 'unsuspected' cases Beck obtained positive reactions in 46·1 per cent. (Pickert).

A. Fränkel, among 68 cases not suspected of tuberculosis, found 56·1 per cent. react (doses 1–3–5 and sometimes 10). Neisser and Pollack, following up their cases positive to tuberculin (doses 1–3–6), without clinical evidence of disease, found them all well after two years. Tillman, among 100 patients reacting to tuberculin, found, after an interval of two and a half to seven years, that one-third to one-half had shown no evidence of clinical disease. Hamman summed up his experiences as follows :—

"We had innumerable cases of early pulmonary tubercle in those days, many more than you could find on our records now. We were further entrenched in our confidence by the confirmatory evidence lent by tuberculin. To give added assurance, we administered tuberculin to these patients subcutaneously. Of about 36 patients so tested at Eudowood all but one reacted. Slight physical signs and the tuberculin reaction played so smoothly into one another's hands that we at last became suspicious and began to give tuberculin indiscriminately to as many patients as we could control,

and to our dismay found that about 60 per cent. of all individuals react, whether they are suspected of having tuberculosis or not."

Thus we find that both the healthy, and patients sick or convalescent from other diseases than tubercle, give a tuberculin reaction in something like 50 per cent. of cases. From this it is obvious that a febrile and general reaction *per se* is of no value in deciding the diagnosis of clinical tuberculosis.

Amount of sensitiveness. It might be, however, that some value attaches to the size of dose to which the patient reacts, and this is to some slight extent the case, as has been already indicated. There is evidence that a smart and prompt reaction to a small dose generally denotes recent and active disease, and that, on the other hand, old chronic processes generally react in a sluggish manner and to larger doses. Thus Junker was able to show, by dividing his cases into three classes, that reaction to decimilligrams generally accompanied a higher activity of disease than reaction to milligram doses. Exceptions, however, were numerous, since among cases of very active disease 21 per cent. reacted only when milligrams were reached, while in cases of low activity fully 17 per cent. reacted promptly to decimilligrams. All the cases with disease of over three years' duration (with two exceptions) failed to react till milligram doses were reached. A rule with so many exceptions cannot be of great value in individual diagnosis; it can only indicate probabilities whose value needs further substantiation (see also Significance of Skin Sensitiveness, p. 148).

Positive results may be, then, roughly divided, according to size of doze and smartness of reaction, into—

1. Positive, with high sensitiveness to tuberculin.
2. Positive, with low sensitiveness to tuberculin.
3. Intermediate cases of all grades of sensitiveness.

In cases coming into Classes 2 and 3 the tuberculin test may be said to have failed; it has demonstrated neither the presence nor the absence of clinical tubercle. Where high sensitiveness to tuberculin is present, we

should be at least suspicious of active disease and diligently review signs and symptoms and apply other tests with a view to corroborating this.

Conclusions. A febrile and general reaction to subcutaneous tuberculin must, then, be interpreted somewhat as follows :—

(*a*) A reaction to the first small dose, or to any decimilligram dose, shows high sensitiveness, a condition generally associated with recent and active disease. It must not be accepted as proof of this, but in the presence of physical signs indicates the need for other evidence of activity such as the fever or autoinoculation test can supply. In the absence of physical signs or other evidence the patient should be kept under observation for a certain period.

(*b*) A reaction to larger doses proves only the presence of former infection, not of disease, and is no indication for treatment.

The Focal Reaction

The focal reaction is the reaction in the focus of disease to tuberculin carried there in the blood-stream, and expresses itself by symptoms, by signs, or by both of these together. Unlike the febrile reaction, of value only where it fails, a positive focal reaction is of very definite value—is, indeed, the very marrow of the application of subcutaneous tuberculin. For it indicates not only the position of disease but also the tubercular nature of this, and is, besides, presumptive evidence that the focus is active or may become so. It also furnishes the one source of danger in the use of tuberculin injections.

Its nature and significance. Those who have treated visible lesions—lupus, scrofuloderma, dactylitis—with tuberculin are quite familiar with the focal hyperæmia which follows the injection, especially where a dose has been sufficiently large to occasion a general

reaction. Hyperæmia in areas of lung disease gives no indications of its presence unless it is marked in degree, when symptoms—increased cough, increased expectoration sometimes preceded by a decrease, chest oppression or pain, breathlessness, stitch in the side, and such like—occur, and signs—the appearance of impairment or râles or both where these were absent before, or the increase of these when already present—arise to indicate its advent. A focal reaction is truly specific since only a tubercular focus can attract injected tuberculin and react to it in this manner. Its appearance is, then, definite proof of the presence of the tubercle bacillus. It seems, moreover, fairly certain that the occurrence of a focal reaction indicates, if not active disease, at least disease which is not cured and which is liable to become a danger to its host in the future. The focal reaction is thus evidence of the need for treatment.

The **value** of the focal reaction as evidence of activity finds acceptance with most authorities. Romberg followed up 200 cases from the Tübingen clinic with the following results: After a period of 1–4½ years (average 2½ years) 47 cases, giving only a febrile reaction, showed 44 remaining well and only 3 with progression of disease. Of 135 cases, on the other hand, where a focal reaction was obtained, no less than three-fifths had got worse and only two-fifths were improved or cured in spite of sanatorium treatment. These results either show that the focal reaction is proof of activity,—Romberg also thinks its failure evidence of obsolescence—or that it exerts so bad an effect on the disease process as notably to worsen the prognosis. The latter suggestion has found no favour among those of wide experience.

Its recognition. In addition to the symptoms already outlined, a well-marked focal reaction gives rise, in most cases, to characteristic fever, the secondary reaction (see Fig. 22, p. 163), and to signs in the chest.

These latter may be appreciable to percussion or auscultation or to both, largely according to the individual skill of the observer. Otten, Kammerer, von Romberg—indeed, the Tübingen school in general—laud percussion as the best method of observation. The last of these found that three-quarters of his cases gave impairment to percussion as against one-quarter with auscultatory changes. Many, of course, gave both. Walterhöfer, Rumpf and Ziegler, and also Bandelier and Röpke, prefer auscultation. Hamman relies solely on the appearance or increase of râles. Walterhöfer, among 60 focal reactions, detected 91·67 per cent. by auscultation and only 8·33 per cent. by percussion.

Such discrepancies must depend mainly on the leanings of the observer to one or other of these methods of examination. There is no doubt that the exact value of a percussion note is more difficult to memorise over several days than is the number of râles audible at a particular spot, since these latter can be roughly indicated numerically. On the other hand, the number of râles depends so largely on the depth of respiration, the recency of cough, and on numerous other factors, and varies so much from hour to hour under normal conditions, that a large element of fallacy hangs on this investigation also. The writer is convinced that the signs of a focal reaction can readily be conjured up when not truly present, and only accepts very decided changes as evidence of its presence. He would also draw attention to the great importance of temperature and symptoms in deciding the point in cases of doubt. Much more easy is it to recognise the reaction when signs appear in a chest where they were before absent, or in areas of the chest, where formerly no evidence of disease was discovered.

The frequency of the focal reaction. Very significant of the fallacy attaching to equivocal signs is the

marked disagreement between different observers as to the frequency of a focal reaction. Romberg, among 324 cases in the Tübingen clinic (see also Otten), obtained focal reactions in the following order :—

Focal with general reaction in	197	cases or	60·8	per cent.
Focal reaction alone in	24	,,	7·4	,,
General reaction alone in	76	,,	23·5	,,
No reaction in	27	,,	8·3	,,

Most of these cases reacted focally to small doses; thus of the 197 cases above quoted 26 to 0·1 c.mm., 37 to 0·5 c.mm., and 52 to 1·0 c.mm. Walterhöfer in 110 cases diagnosed as active disease obtained a focal reaction in 60, or 54·5 per cent. Hamman among 63 cases reacting to tuberculin found well-marked focal reaction in 14, and suggestive signs in 9 more, in all 36·5 per cent. In 13 cases with definite pulmonary signs 8 gave increased râles, 4 no change, and in 1 the signs cleared up to return later. Möller and Kayserling obtained focal reactions in 35 per cent. of their cases, A Fränkel in 10·8 per cent., Petruschky "sometimes." Fritz Junker found it for certain in only 10 of 270 cases reacting to tuberculin, or 3·7 per cent., but this was among ambulant patients who could not always be caught at the right moment. From observation of superficial lesions we know that a visible hyperæmia occurs to quite small doses of tuberculin; but in cases of lung disease a focal reaction of size sufficient to decide a diagnosis will be found in considerably under half the cases giving a general reaction.

Appearance of tubercle bacilli in the sputum after a focal reaction. Much has been said about the importance of this for diagnosis, but in practice it comes about but seldom. Junker obtained them only 4 times among 270 cases injected, Löwenstein and Rappoport in 19 of 386 cases, Otten in 3 among 324 cases. They should, however, be looked for where the sputum is increased.

Danger of the focal reaction. The danger of subcutaneous tuberculin is the danger of the focal reaction, and careful consideration of this point is of the highest practical importance. That a focal reaction induced by a dose of tuberculin may lead to serious spread of disease and start uncontrollable fever there is abundant evidence to show. The writer has had cause to observe several lamentable examples; Fig. 23 illustrates well both the occurrence and its causation. The latter has been, in all cases observed by the writer, neglect to follow the simple rules laid down for the administration of tuberculin—neglect as a rule of the contra-indication fever, and neglect to repeat instead of increasing the dose in cases where a doubtful reaction has occurred. Dangerous reactions in the hands of experts, and where contra-indications and directions for administration are faithfully observed, are rare, and do not suffice to condemn the method when applied with adequate skill.

Bandelier and Röpke never saw harm, or fever lasting as long as a week, among 10–12,000 injections given by themselves. Penzoldt, with experience of many thousands of tests, found that danger could be entirely eliminated by care. Von Romberg and Otten never encountered ill results from focal reactions among their cases. Fritz Junker has failed to find permanent damage in spite of considerable general disturbances; he is of opinion that it may be safely used under the following precautions: prolonged observation of the temperature beforehand, full knowledge of the method, needful attention to contra-indications, and careful control of the patient during the time the test is being applied.

Where serious results are described these are nearly always referable to carelessness or ignorance. Thus Ulrici's cases of harm following marked reactions were attributable to the fact that the tests were made on cases of definite phthisis in all stages from first to third.

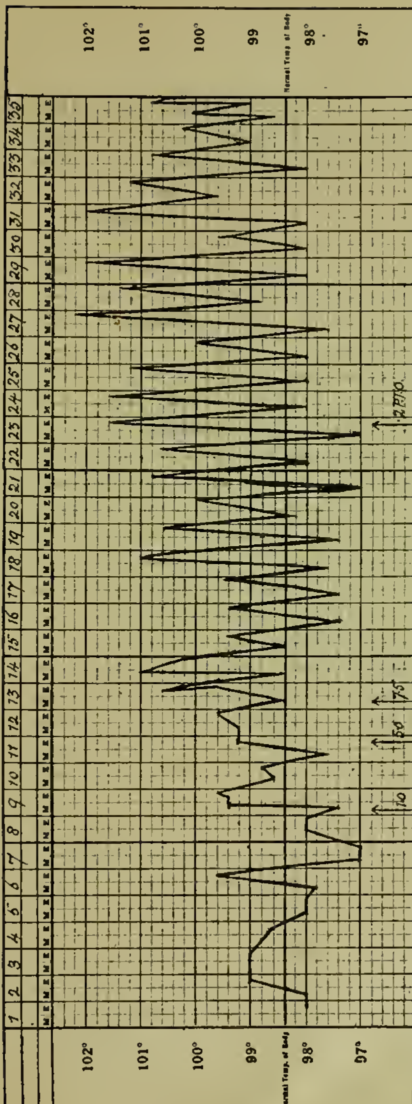


FIG. 23.—Disease rendered acute by diagnostic tuberculin; illustrates, among others, the following faults: (*a*) needless administration, since the case was one of well-marked phthisis; (*b*) increase of dose to 7·5 c.mm., though 5 c.mm. was followed by marked general symptoms.

For an interesting example of neglect of rules and contra-indications, and the result of this, the reader is referred to the cases of Prof. Schüle (*Beiträge zur Klinik der Tuberkulose*, 1903–4, II. 69) and the comments thereon by Köppen (p. 225), Köhler (p. 235), and Servaes (p. 243). Hamman describes spread of disease after reaction in two cases of definite tuberculosis, and urges caution.

The writer has seen so many cases where needful care in the use of diagnostic injections has been neglected with harmful results, that he is very strongly of opinion that subcutaneous tuberculin for diagnosis should be given by those whose special knowledge of this branch of work fits them duly to avoid the dangers and to interpret the results.

GUIDE TO THE USE OF THE TUBERCULIN TESTS

So much paper has been unavoidably covered in the attempt to put each of the tuberculin tests on its proper footing that a short practical *résumé* seems called for to show how the tests should be employed in the diagnosis of early phthisis.

In all cases **where fever is absent,** and no other contra-indications exist, **subcutaneous injection** is the test *par excellence.* In the first place, it may provide us with one or other of two sure pieces of evidence: there may be a focal reaction when, if well marked, a diagnosis of active disease may be made with some confidence; the subcutaneous test may fail altogether, when we are in possession of valuable evidence that active disease is not present. Hamman was able to point to 26 among 75 suspected cases (nearly 35 per cent.) in which such positive information on one side or the other was obtained by subcutaneous injection, in 12 a negative result, and in 14 a focal reaction. Such

a proportion of definite results is sufficiently large to make the use of this test worth while in carefully selected cases. Failing these results we shall obtain a febrile reaction alone, a discovery of no value in diagnosis unless liberated to a first small dose, when it implies a high tuberculin sensitiveness and therefore a certain probability (see p. 165) of active disease.

Where contra-indications to the use of subcutaneous tuberculin are present, we are left with methods capable of giving only uncertain evidence of the presence of active disease. By the **quantitative cutaneous test** (p. 139) a fair estimate of the amount of skin-, and probably also of general tissue-sensitiveness can be obtained, and this will be a factor of more or less value in the sum of evidence for or against the disease. In the combined use of **conjunctival and skin reactions** (p. 155) there is a chance that we may obtain evidence of probable active disease on the one hand or of probable absence of such on the other, but in either case we are again dealing with probabilities only.

Finally, it must be remarked that, like all other special tests, the tuberculin tests should be used intelligently if at all, and with some definite purpose in view. They are contra-indicated where disease can be diagnosed without them, as in such a combination as a brisk hæmoptysis with characteristic physical signs at one apex. Such a combination raises the probability of tubercular disease so high that it is best to avoid the possible disadvantages of the subcutaneous test, and futile to seek the unsubstantial evidence given by the remaining methods. Where the evidence from other sides is equivocal, we may turn to tuberculin for information of three different kinds :—

(i) The presence of a focal reaction.
(ii) The exclusion of active disease.
(iii) The degree of tuberculin sensitiveness.

THE TEMPERATURE

Though the thermometer plays a well-recognised rôle in the observation and control of tuberculosis through all its stages, it is apt to suffer neglect as a means of diagnosis. Only too often the specialist can obtain but word-of-mouth information on that important point the temperature, or at most a few isolated observations are submitted in a case which has been under medical supervision for many weeks. The complete symptomatology of a case must always include a well-arranged temperature record, and this proves of the utmost value alike to diagnosis, prognosis, and treatment.

How and when to take the temperature. In a matter of such manifest importance as the diagnosis of phthisis it should not be too much to expect that a two-hourly temperature chart be kept, at any rate for a week or two. The time at which fever occurs cannot be foreknown, and Cornet has pointed out cases where the temperature though normal at 8, 12, and 6 was yet distinctly febrile at 3 p.m. Nothing less than a two-hourly observation will ensure the recognition of such a rise, and Cornet, Minor, and others support the dictum of Brehmer that such a two-hourly record is needed to exclude fever.

Where such a record is impossible to obtain, as may happen at times, a convenient compromise is the determination of the highest point on two or three consecutive days and the preparation of a four-hourly, or even morning and evening chart, which takes in this

time for the afternoon record. Where the temperature is only taken twice, the first observation should be on waking in the morning, since a subnormal temperature at this time is sometimes a characteristic of phthisis in its early stages; the second observation should be at the highest evening point, generally between 5 and 8 p.m. It must be remembered that early phthisis often shows afebrile periods and, for certainty, it may be necessary to continue temperature observations for three or four weeks.

It is well that a 'certified' thermometer be used in all cases where temperature is likely to be an important factor, and that unexpected or doubtful readings be verified by the use of a second instrument. Fishberg in America recorded very unsatisfactory results from the comparison of different thermometers. He found that "simultaneous observations made on a single patient with two instruments often disclose a difference in readings of ·75° to 2°. The simultaneous immersion of two dozen thermometers in a bath of warm water disclosed that the readings varied from 98·2° to 101·6° F.; and another similar batch of higher-priced thermometers in another bath showed variations of temperature between 98° and 105·4° F." Even the 'certified' instruments proved little more reliable; in cases of unexplained fever the thermometer must evidently be suspect until its reliability has been proved.

Where to take the temperature. There is no doubt that the rectal temperature is the most accurate. Such authorities as Jürgensen, Liebermeister, Cornet, and Lawrason Brown recommend its use; Turban and Charles Minor are content with mouth temperatures. The latter resorts on occasion to rectal temperature as a control, and finds that the mouth temperature runs parallel with it though half a degree lower. Not only is the rectal temperature more reliable, it is also more

quickly taken; five minutes at most are required, whereas the mouth requires ten to fifteen minutes, and must be kept closed some time beforehand to ensure accurate results. The mouth temperature generally reads low in a cold atmosphere and after exercise against the wind; moreover, where the nose is blocked no accuracy can possibly be obtained. The axillary temperature is the lowest of all, and here also, for accuracy, the space must be kept closed with the arm held to the side for some time before the thermometer is inserted. In male patients an accurate temperature can be taken in the stream of urine, a very few moments of contact sufficing for this. Pembrey and Nichol found that the passage of only 82 c.c. of urine over the bulb of the thermometer sufficed to raise the mercury to its highest point.

Influence of location in thermometry. It must be noted that the location of the thermometer exercises an important influence on the height of the temperature obtained, though the disparity varies somewhat in the figures of different observers.

Zeimssen found the rectal only 0·2° C. (0·36° F.) higher than the axillary temperature; Liebermeister recorded differences of 0·1° C. (0·2° F.) and 0·4° C. (0·7° F.) between them where the axilla was kept closed for a long time before the experiments were undertaken, otherwise the difference was much greater.

The mouth stands midway between rectum and axilla. Bardswell and Chapman found the resting rectal 0·9° F. higher than the mouth and 1° F. higher than the axillary temperature. The urine, on the other hand, approached within 0·23° F. of the rectal. Minor notes a difference of about 0·5° F. between mouth and rectum. Pembrey and Nichol found for a series of observations, which included rest, food, and exercise temperatures, that on an average the rectal temperature was higher than the urine by 0·26° C. (0·48° F.), than the mouth by

0·65° C. (1·17° F.), and than the axilla by 0·23° C. (0·41° F.) (the axillary did not include exercise temperatures); the urine temperature was 0·46° C. (0·82° F.) higher than the mouth. The difference between rectum and mouth was, no doubt, accentuated in these observations by the inclusion of exercise temperatures among the observations.

These collected results indicate the importance of qualifying all temperature records with a statement of where they are taken, and also of making due allowance for the differences depending thereon. It appears certain that at least 0·5° to 0·75° F. must be allowed for the difference between rectal and mouth temperatures during conditions of rest.

THE RESTING TEMPERATURE

Normal. The utmost importance and the utmost difficulty attaches to the determination of the temperature in health and of its normal fluctuations. The question which assails us when we are confronted with a case of doubtful phthisis is generally the following: "Are the variations of this temperature within the limits of health, or do they show a definite abnormality which demands other explanation?" The answer is, at times, most difficult to give. Not infrequently a temperature chart is the matter which has caused anxiety, and on which the specialist is required to decide. At times such charts show temperatures which are really within the normal range, or the effect of exercise and meals (see case quoted below) has not been taken into consideration; at other times the temperature pushes the normal limit so close that it becomes a really difficult matter to decide whether, taken by itself, it should be considered abnormal or not.

A doctor, aged 37, was seen in 1912 with a history of pleural effusion preceded by dry pleurisy a year previous. He had remained well, but had permitted himself to be tested with tuberculin, which was given in quite ineffectual doses but was said to be followed by

fever—99° F. mouth, and later evening temperatures of 99·6° F. and 99·8° F. This so perturbed him that he travelled some 200 miles to London for advice. It then appeared that the temperatures causing anxiety had always been taken directly after exercise; there was no evidence of disease, and he was reassured. A year later he was well and his temperature normal.

Wunderlich justly remarks that " when every precaution has been taken in making the observations, it is impossible to draw a hard-and-fast line to indicate by the temperature the exact limits of health and disease." Nevertheless, to make thermometry of value in the diagnosis of phthisis, we must come as near to this as we can, and, fortunately, a large amount of work has been done at different times on the normal temperature in man.

Wunderlich himself put the range of normal temperature in the axilla between 97·25° F. and 99·5° F., and the mean normal temperature at 98·6° F., but it seems likely that his observations are vitiated by the fact that he included convalescent patients among his material. The most notable observations are those of Jürgensen in 1873, and he especially established the fact that the mean temperature (98·9° F. rectal according to him) varies hardly at all between individuals, nor in the same individual from day to day. A rise due to exercise is balanced by a compensatory fall. The minimum and maximum ranges (rectal) among his two controls, kept in bed for the purpose, were—

36·45° C. (97·6° F.)	36·3° C. (97·3° F.)
37·7° C. (99·8° F.)	37·7° C. (99·8° F.)

The average of the maximum and minimum temperatures obtained in these two cases were, according to Liebermeister—

36·7° C. (98° F.)	36·4° C. (97·5° F.)
37·5° C. (99·5° F.)	37·7° C. (99·8° F.)

Liebermeister puts the mean at 36·89° C. (98·4° F.) in

the axilla, and finds the upper limit in the case he studied at 37·4° C. (99·3° F.).

Gierse gives the minimum and maximum at 36·81° C. (98·2° F.) to 37·5° C. (99·45° F.) in the mouth; Bärensprung 36·31° C. (97·3° F.) to 37·48° C. (99·4° F.) in the axilla.

Vierordt finds the normal to range between 36·25° C. (97·3° F.) and 37·5° C. (99·45° F.), but considers a persistent evening rise to 99·2° F. as fever if the digestive tract is normal. Cornet points out that in some the normal barely reaches 98·6° F., and a rise to 99·1° F. denotes a febricula. These appear to be rectal temperatures, and he remarks that anything over 99·5° F. must be regarded as fever.

Turban considers 99·3° F. (mouth), at rest and recurring, as fever.

Pembrey and Nichol, from observations on themselves, found the minimum at 96·8° F. and 96·9 F., and the maximum 100·6° F. and 100·1° F. respectively; but these were not true resting temperatures. The average lowest and highest on the day's curve showed 97·05° F. and 99·25° F. (rectal) for one of them, and 97·25° F. and 99·58° F. (urine) for the other.

Bardswell and Chapman obtained very different results on resting people: they found that the average for waking hours was 98·5° F., and for sleeping hours 97·2° F., and in no case did the temperature rise above 99° F. These temperatures were rectal, but they lie so much below those of all other observers as to call for special comment. The only published figures in any way comparable are those of John Davy, taken on himself in the year 1845. These were mouth temperatures, and varied from a minimum of 97·6° F. to a maximum of 98·9° F.

Conclusions. Consideration of this series of observations brings us to the conclusion that the resting normal temperature is not so hard-and-fast a figure as some clinicians would have us to suppose, and that slight excursions beyond must be viewed with a broad judgment.

Especially must it be remembered that the temperature is readily influenced by certain features of daily life, and rises perceptibly after meals (especially the mouth temperature), and as a result of exercise (see p. 182); is affected by the climate and temperature of the air—John Davy found it 1° F. higher in the tropics than in England, and Pottenger notes a lowered temperature on cold mornings—by baths, hot or cold; and, in susceptible people, by constipation or the reverse. Moreover, in people of nervous temperament, women and children, great mobility is observable, so that apparently causeless elevations readily occur (see p. 285).

Finally, in women the period of menstruation is normally preceded by a week or ten days of raised temperature, which falls again when the catamenia commence.

This is the common type, and occurs, according to David Lawson, in 85–90 per cent. of cases. The remainder of the cases fall into two groups: (*a*) those whose temperature is unaffected by menstruation (5 per cent.); (*b*) those in whom the rise occurs at the onset of the period and remains high for four or five days (10 per cent.).

In cases where the health temperature of the suspected individual is to hand it is, of course, easy to decide what constitutes a departure from this. Failing this opportunity, we must content ourselves with an arbitrary standard deduced from general observations.

The normal in practice. For practical purposes the minimum and maximum of the normal range may be considered at 97·2° F. to 99·5° F. (rectal), and anything outside these figures calls for comment or demands explanation. It is well, however, to bear in mind that so careful an observer as Jürgensen found temperatures as high as 99·8° F. (rectal), on occasion, in healthy

people at rest. A clear distinction must, however, be made between an isolated rise and an evening temperature which persistently pushes the normal limit so closely.

Mouth temperatures may be calculated for at least 0·5° F. below these figures, and thus give a range of 96·7° and 99° F. The daily fluctuation in health is commonly about 1° F., but it may range as high as 1·5° F. in normal individuals. Lastly, it must be noted that after exercise the temperature may take nearly an hour to fall to the resting figure.

Fever in Early Tuberculosis

Any departure from the normal range of temperature indicated above must be held sufficient to demand an explanation, of which tuberculosis may or may not be the right one. There is no kind of fever distinctive of tuberculosis, but there are often certain elements about its temperature changes which are somewhat characteristic of this disease. This instability of temperature is often a noticeable feature, such slight causes as reading, writing, a game of cards, mental worry, a thunderstorm, and the like, leading to fever. A low morning temperature, to 97° F. or under, often accompanied by a slight evening rise, the whole fluctuation being excessive, is a common characteristic of tuberculosis in its early stages. This condition may be accompanied by a pulse frequency out of proportion to the thermometric change. The importance of this increased swing of temperature as evidence of fever must be clearly recognised. Fishberg has remarked that " a patient with a temperature of 99·8° F. at 5 p.m. has not only 1° above normal when his morning temperature is 96·5°, but 3·3° above normal, and should be considered febrile." This is to put it strongly, but the loading, if any, is on the right side of the balance.

Another point which has been remarked about the fever of tuberculosis is the curious retention of appetite in its despite. One writer has declared that "all patients who eat and digest their food well in spite of fever are consumptives," and Fishberg remarks in support that "anorexia is a constant accompaniment of fever, excepting the fever of early phthisis." This physician also relies on appetite in the differential diagnosis between pneumonia and acute pneumonic phthisis; "in pneumonia," he says, "anorexia is invariably complete, while in acute phthisis the appetite may be retained more or less, and in spite of a temperature of 103° F. or 104° F., the patient is apt to ask for nourishment."

The discovery of a normal temperature must not be taken as evidence of health, for early phthisis may be afebrile, at least for a time, and it is in such cases especially that the result of exercise, first suggested by Penzoldt, may give valuable information which would be otherwise lacking (see p. 183). It is important also, as has been already pointed out, that, in the presence of a normal temperature where the symptoms and signs are otherwise suspicious, thermometric observations should be continued over a period of some weeks, three or four for safety.

EXERCISE TEMPERATURES

Normal. Of the utmost importance is it to realise the effect of exercise on the temperature. This was first investigated by John Davy, who carried out observations on this subject in Constantinople as long ago as 1841. He was not impressed with the effect of moderate exercise, which he said "augments very little, if at all, the heat of the deep-seated parts"; active exercise, however, he found to raise the temperature "proportionate to the degree of muscular exertion made." Later

investigators have confirmed the truth of these observations. Professors Liebermeister and Hoffmann climbed the Weissenstein (1,280 metres), taking their axillary temperatures at intervals; that of Prof. Liebermeister rose at greatest from 36·82° C. (98·2° F.) to 37·85° C. (100·1° F.); and that of Prof. Hoffmann from 36·5° C. (97·6° F.), to 37·95° C. (100·4° F.).

Among high readings after considerable exertion may be quoted that obtained by Obernier in 1867. A fast walker covered the distance from Bonn to Godesberg and back, a reputed two-hours' walk, in one hour of time. His rectal temperature rose to 39·6° C. (103·2° F.), but had fallen to 39° C. (102·2° F.) seven minutes later. Leonard Hill and Martin Flack recorded temperatures of 103·6° F., 103·8° F., and 105° F. in athletes after a three-mile running race. Bardswell and Chapman never observed a higher temperature than 103·4° F. as a result of exercise. These observers found as a result of many observations in healthy men that two miles' walk in one hour raised the temperature 1° F., four miles' walk 2·1° F., and six miles' walk in one hour 4·3° F. Running had rather less effect.

Exercise Temperatures in Pulmonary Tuberculosis

The idea of utilising exercise to bring out fever, not present otherwise, in cases of suspected early phthisis first originated with Penzoldt. It is common knowledge that exercise very readily induces fever in patients with tuberculosis, and the utilisation of this fact in cases where the diagnosis or the activity of the disease is in question should not be neglected. Since a rise of temperature is an invariable accompaniment of exercise in the healthy, it is obvious that due allowance must be made for this before any inferences are drawn in cases under suspicion of tuberculosis. In phthisis two factors will be present:—

1. The physiological rise of temperature due to exercise.
2. Temperature in excess of this due, probably, to toxins carried out from the tubercular focus into the blood-stream, whether mainly bacterial or in part produced by autolysis of the diseased tissues.

It is needful that the first should be allowed for before we can determine whether any evidence of the second factor is obtainable. This can be accomplished by setting the patient some task the effect of which on the healthy has been already tested and measured. Thus the figures of Bardswell and Chapman, already given, can be utilised, and the patient set to walk a measured distance in a certain time. Hochstetter uses a somewhat different test. He finds that light work will not (and heavier work hardly) cause a rise above 37·8° (100° F.) rectal in the healthy. A rise of temperature to 100° F. on such work he considers suspicious, and any figure above this distinctly normal. But the determination of what constitutes light and what heavy work is too fallible to give practical issues.

A much better means of applying **the fever test** is suggested by some experiments carried out by the same writer. He arranged a walk from Erlangen to Rathsberg and back, a distance of 6 kilometres (3¾ miles), with a rise of 330 metres, and marched his patients and controls over the distance slowly, the time taken being 1¼ hours. The temperature was taken in the rectum before starting and on return. Ten journeys in all were undertaken among six phthisis patients and four controls, some three to five observations being obtained from each individual. All the phthisis cases were afebrile at the start. The average rise among the controls was 0·54° C. (0·97° F.), while among the phthisis patients it was 0·9° C. (1·6° F.), or nearly double. In only one of the phthisis cases was the rise within the limits obtained in the healthy; this was due prob-

ably to tolerance to tubercle toxins, a condition little likely to occur in early tuberculosis.

Bardswell and Chapman find that a consumptive in good condition will even show a lower temperature than the healthy control after exercise, a condition difficult of explanation but again little likely to occur with incipient disease.

The fever test in practice. We have here the suggestion for a very reliable and practical method of carrying out the fever test in any suspected case. The control may be an attendant or nurse, of known physical soundness, and the sole requirement of the test is that patient and control should share whatever exercise or labour test is decided upon. The temperatures must be taken in the rectum, for mouth temperatures after exercise are no criterion of the internal body heat. The difference in rise of the rectal temperature becomes, then, the measure of the evidence of active disease in the case under observation. Such a test is especially applicable to cases where the activity of a focus is in doubt, or where a subcutaneous tuberculin test has proved positive to small doses without corroboration from clinical signs. Where evidence of chronic disease is present the possible effect of tolerance leading to a negative result must be taken into consideration. Apart from other proof of tubercle it must be borne in mind that fever obtained under these conditions is no specific test, as is the tuberculo-opsonic power, to which attention will be given in the succeeding section.

THE AUTOINOCULATION TEST

This test aims at supplying an answer to the question, "Is there a focus of active tubercular disease somewhere in the body?" Or in other words, "Is there a supply of autotuberculin within reach of the blood-stream?" The determination may be arrived at in more than one way. The whole symptomatology of phthisis is, to be sure, the most explicit answer to the question, and, in so far as the symptoms are characteristic of the disease, they offer a valuable help in diagnosis. But there is nothing truly specific about these symptoms, and although collectively they may supply grounds for strong suspicion, they are never in themselves evidence for even so much as a provisional diagnosis. Given some proof of their tubercular causation they are, to be sure, a witness to activity. Especially is this the case with the body temperature, whose fluctuations under varying conditions of rest and exercise furnish us (mixed infections apart) with a convenient measure of autotuberculin dosage. This has been already discussed in the foregoing section.

TUBERCULO-OPSONIC DETERMINATION

There remains an element of the autoinoculation test which is more truly specific in character, namely the determination of the tuberculo-opsonic power of the blood. This power belongs, of course, to healthy bloods, and it is to departures from the normal standard under conditions of disease that we look for evidence which can be utlised in diagnosis.

The practitioner must be warned against placing too much reliance on this evidence. Experimental error is, unfortunately, so large that individual observations are always liable to be misleading, although collective investigation has led us to such profitable conclusions. It is on account of this error solely that the opsonic index has fallen so greatly into disuse, and fortunately the diagnosis of phthisis can always be accomplished without its aid. Nevertheless, there are cases where this evidence, especially where money and trouble are of no account, may be worth having, and it behoves the physician to study carefully its applicability and limits. The opsonic index has been by some too much cursed, by others too greatly caressed. Its findings in skilful hands, and on the lines to be presently laid down, may be of value when rightly interpreted, but they must be viewed in their right perspective, and the results never divorced from those obtained by clinical examination and other methods.

The avoidance of experimental error. No details of the opsonic methods are here required. It may, however, be remarked that for reasonable accuracy at least 200 bacilli should be counted in each observation, whatever the number of the cells containing them, and the clinician can insist that the pathologist supplies him with at least this amount of insurance against error. Furthermore, it has recently been shown by Hayden and Parry Morgan that considerable fallacies may arise from omission to make sure that the emulsion of tubercle bacilli used is fully sensitive to fluctuations of opsonic content both above and below the normal level. In the case of high indices a sufficiency of bacterial detritus needs to be present to supplement the supply of receptors furnished by the bacilli in the comparatively thin emulsion it is convenient to use; neglect of this requirement will suffice to explain the diversity of results obtained by different workers with the same blood and, on occasion, by the same worker at different times.

Readers are referred for details to the original paper (see Bibliography).

Preliminary considerations. There are three points about the tuberculo-opsonic index which must be borne in mind before we can consider its value in the diagnosis of phthisis :—

1. The index of normal individuals is found to lie persistently within the limits of 0·8 and 1·2 (Bulloch). This is probably as near as experimental error warrants, though some observers have drawn the lines somewhat closer, as 0·85–1·15 of Wolff and Reiter of Berlin, and of H. M. King of Loomis.

2. The index in localised tuberculosis is generally low; in phthisis it is generally either below or else above the normal limit, and often fluctuates.

3. The index is affected by injection of tuberculin in a characteristic manner. After a fall, the 'negative phase' (often preceded by a short rise), of varying amount and duration, it rises as the 'positive phase' well above the normal line, and later falls to its original or a slightly higher level.

The last two of these three points introduce us to a theoretical consideration which has profoundly influenced our whole outlook on tuberculosis. **The conception of "autoinoculation"** was initiated by Wright in 1905. He noted the spontaneous fluctuations of the opsonic index in cases of tuberculosis with fever, and suggested as its cause an inoculation with tuberculin from the area of disease, or 'autoinoculation.' No idea in medicine can have been more loudly acclaimed or more widely exploited. Freeman soon after supplied evidence of artificial autoinoculation in the fluctuations produced by massage of a diseased joint, and similar evidence was soon collected for physical exercise, operations, and induced hyperæmia. Patterson and Inman applied the principle to therapeutic use, and the latter worker has especially brought to the front the

method of artificial autoinoculation in the diagnosis of phthisis.

But little ingenuity is needed to connect the application of the three points given above with the diagnosis of phthisis. The information we require comes mainly under the folllowing heads :—

(*a*) Is the index within normal limits on two or more examinations?

(*b*) If outside—is it low, high, or fluctuating?

(*c*) Can we affect it by hyperæmia (through exercise, etc.) of the diseased focus? In other words, can we produce a specific autoinoculation?

The method. If trouble and expense are no deterrent, it is as well to begin with the determination of two or three indices under normal conditions. If these are fluctuating and outside the normal limits all the evidence we need is at hand—namely, that of spontaneous autoinoculation. If, on the other hand, the index remains level either at the normal, or below or above this, an artificial autoinoculation is called for; or this may be done at the beginning without preliminary study of the index. The autoinoculation can be produced by exertion sufficient to flush the diseased parts and wash out a good dose of the toxin. A brisk walk may suffice; the writer has found it to fail in many cases. More certain, in pulmonary tuberculosis, is the use of a suction mask, readily improvised from the face-piece of an ordinary ether apparatus by reducing the inlet to a minimum, and this should be used with forced respiration continued over a period of some minutes. By this means sufficient disturbance of the lung focus and liberation of antigen generally occurs to alter the supply of opsonic antibodies in the same way as a tuberculin injection. The blood should be taken **before** the test; **one hour after** to hit off the first fluctuation, which may be negative phase, or sometimes pre-negative rise;

and again later, preferably twice, the first to hit off the positive, or failing this a continued negative phase, the second in most cases a positive phase. These may conveniently be **six hours** and **twenty-four hours after.**

It is obvious that the amount of autoinoculation must be suited to the nature of the case; where disease is very chronic or partly healed, or after a course of tuberculin, considerable exercise may be insufficient to produce a fluctuation of the index. In cases of earlier or acute disease, on the other hand, the test may readily be overdone, and definite illness result. H. M. King describes cases where continuous fever and focal reactions followed the test, and though these may have helped the diagnosis, their production can only be condemned as highly undesirable and needless.

Results of the method. These may be conveniently divided into those obtained from the examination of the tuberculo-opsonic index under ordinary conditions, and those dependent on artificial autoinoculation tests.

The Natural Index

Wolff and Reiter as a result of testing a large number of phthisis cases were able to make the following rough distinction :—

(*a*) Chronic or nearly stationary cases show a moderately low index, about 0·7 as an average.

(*b*) Progressive cases show a very low (0·3 or 0·4) or a fluctuating index.

Low indices were commoner than high among their cases, as the following table shows :—

Low index. 62 per cent. at one examination, 57 per cent. at two or more.

Raised index. 25 per cent. at one examination, 12 per cent. at two or more.

Normal. 12 per cent. at one examination, in no case at two or more.

The following important contrast is brought out by the table given above :—

In normal individuals the index remains within normal limits at every examination.

In tuberculosis the index may be low or high, but if normal at one examination it never remains so to repeated tests.

Care must be taken that reliance is not placed on slight fluctuations, or slight departures from the normal in the opsonic index. Experimental errors are large, even in the hands of a highly-trained and conscientious pathologist, and, where as many as 200 bacilli are counted in each slide (the minimum for accuracy), an error of 20 per cent. in the results is probably common. No information should be supplied to the laboratory with the bloods, and these may be numbered out of sequence, the results being rearranged later with a key. Results are useless, save in the hands of workers thoroughly skilled in this particular technique.

Artificial Autoinoculation

As a result of autoinoculation tests Inman was able to divide tubercular cases into four groups :—

A. Low index, rising after exercise.
B. Low index, failing to rise after exercise.
C. High index, falling after exercise.
D. High index, remaining high after exercise.

In these groups he finds A and B correspond to chronic and localised cases, and C and D generally to cases of greater activity. It seems likely that the existence of Group B might arise to a large extent from insufficient autoinoculation, in some cases perhaps avoidable, but in others depending on the supply of autotuberculin in spite of all exertion remaining below the needful dose.

The difficulty always is to decide in practice the amount of exertion justified and necessary in the particular case. Some may need a longish walk or wood-chopping, in others the slightest excess above the normal routine suffices. A few minutes negative pressure with a suction mask supplies the most rational method of inducing autoinoculation in lung disease, but, failing this, exercise will generally suffice. Warren Crowe by a series of indices, spaced in suitable relation to very definite autoinoculation, obtained most striking fluctuations on the lines already laid down as those characteristic of a tuberculin infection. Thus some of his series read: 0·85 (before autoinoculation), 1·15 (one hour after), 0·7 (six hours after), 1·3 (next morning). Other series: 1·1, 1·2, 0·3, 0·75; 1·0, 1·3, 1·05, 1·6; 1·2, 2·1, 1·2, 1·3; etc. These figures are sufficiently characteristic to inspire confidence in the result of the test, but this is far from being the case with some of the figures supplied by workers in this field. He claims, among twenty-three cases of phthisis examined thus with a view to diagnosis, that in every case a definite answer was given, and in no case was there evidence that the verdict was wrong.

Recapitulation. To recapitulate the foregoing shortly, the opsonic autoinoculation test should be applied as follows:—

1. Spontaneous autoinoculation may be tested by a series of indices (two or more), and definite fluctuations render further proceedings needless.

2. If this fails an artificial autoinoculation may be induced by exertion, and the effect on the index tested.

Fluctuations of but two or three points should be disregarded or treated with suspicion; it is only when a characteristic or explainable curve has been obtained that the result can be accepted with confidence.

THE SPUTUM

EXAMINATION FOR TUBERCLE BACILLI

In the diagnosis of pulmonary tuberculosis examination, and constantly repeated examination, of the sputum must be carried out, for though in early disease no real lung sputum may be obtainable, yet cases may still present difficulty in diagnosis where the sputum already contains the bacillus. Nevertheless, it must not be supposed that the discovery of the tubercle bacillus is indispensable to the diagnosis of pulmonary tuberculosis. So long ago as 1890 it was clearly recognised that the disease could be detected before the appearance of bacilli from physical signs alone, and our diagnostic armamentarium has become greatly expanded in the subsequent interval. Thus Grancher (1890) remarked: "In ordinary phthisis the appearance of bacilli in the sputum is tardy. It is preceded by physical signs of the first stage, often complete enough to establish a diagnosis"; and Gerhardt (1890): "I know cases in which bacilli were not found for months, or only in the sixtieth specimen, but where the diagnosis of tuberculosis was established by examination of the chest." Turban (1894) declared that "clinically the first stadium of tuberculosis of the lung may be demonstrated before bacilli appear in the sputum." Disastrous is it to wait for the advent of tubercle bacilli to establish a diagnosis; still more disastrous to regard a negative sputum examination as evidence that the patient's disease is not tuberculous. For only a

positive examination is of decisive value in diagnosis; the significance of a negative result varies with the nature of the individual case, but repeated negative findings cannot exclude the presence of tuberculous disease of the lungs.

Since, however, the positive result is of such surpassing value, we must neglect no opportunity of obtaining it. Frequent examinations must be carried out to that end, and thus we may escape the just reproach attaching to the disclosure of Pickert that among forty-six cases with tubercle bacilli in the sputum, in only nine were they discovered before the patient's admission to sanatorium.

Collection of sputum. The sputum presented for examination is often well-nigh useless from gross dilution with buccal secretions. It must be coughed up deep from the lungs, best in the early morning on rising. If it is scanty, as may occur in early cases, small doses of potassium iodide given for a couple of days may increase it; or an opiate given the evening before may help the patient to retain it through the night ready for morning expectoration.

CONCENTRATION METHODS

The first attempt to bring the sputum into solution with a view to sedimentation was made by Biedert in 1886 by the use of caustic soda and heat. This method found many subsequent improvements, but it was not till 1908 that the more perfect modern methods appeared.

The Antiformin Method of Uhlenhuth

This method was introduced by Uhlenhuth and Xylander in 1908. Antiformin is a mixture of sodium hydroxide and sodium hypochlorite, used by brewers in the disinfection of their fermentation vats and pipes. Its action depends on the oxidation of organic matter

and is so powerful that all but hair, wax, fat, and cellulose are brought into solution. On adding it to sputum there is a marked liberation of gas, the sputum rises to the top of the mixture and rapidly dissolves, the resulting solution being homogeneous, and of yellowish colour, with a small amount of flocculent sediment. All ordinary bacteria are rapidly destroyed, but the tubercle bacillus is protected by its fatty capsule and will retain its virulence for twelve days in 8 per cent. solution and four days in 20 per cent. solution, with no diminution of its staining properties.

Uhlenhuth used simple sedimentation, but this may be hastened by the addition of alcohol in bulk so as to reduce the specific gravity of the mixture. The centrifuge may also be applied with advantage. Seeman ingeniously introduced the original sputum as a fixative of the sediment on the slide, thereby allowing a view of the other organisms in the sputum and at the same time providing a blue ground on which to focus. Boardman, after a careful trial of all the various methods of procedure, recommends the following:—

Process. 1. Place the entire twenty-four hours' sputum in a conical settling glass; if the amount is excessive use 15–20 c.c.

2. If the sputum is thick add an equal quantity of distilled water; less tenacious sputa need less dilution.

3. Add antiformin in quantity equal to one-fourth that of the diluted sputum, so as to make a 20 per cent. solution.

4. Stir thoroughly and stand till solution is homogeneous. This will usually require from ten to sixty minutes, but the tubercle bacilli are not harmed even after days.

5. Add an equal quantity of 95 per cent. alcohol, by which sedimentation is hastened and rendered more complete.

6. After stirring allow to stand till sedimentation is complete. Two to four hours may be enough, but twelve to twenty-four hours is better.

7. Pour off the clear supernatant fluid.

8. Make a smear from the original sputum and spread the sediment from the sputum-antiformin mixture on the same slide. Stain and examine in the usual way. Care must be taken that acid-fast rods sometimes found in these preparations, and probably fat needles, are not mistaken for tubercle bacilli. They are distinguished by being larger, straighter, and more markedly translucent.

Lorenz heats up the mixture after it becomes homogeneous and then centrifuges, and Schneider gets better results with this method than with any other. Its details are as follows :—

1. To 5 c.c. of sputum add 15 c.c. of 15 per cent. antiformin.

2. Shake till the mixture is homogeneous.

3. Heat up to boiling point.

4. Centrifuge for ten minutes and examine the residue.

Results. As regards the results of the antiformin method Boardman found, from a review of the literature, that it enabled tubercle bacilli to be demonstrated in from 7·3 to 17·2 per cent. of specimens found negative by the older methods of examination. Among seventy-three cases of clinical phthisis examined by himself thirty-one were positive to ordinary methods. Among these antiformin caused a great enriching of the slide, so that where by the old method 25 tubercle bacilli could be counted in two minutes, by the antiformin method 138 bacilli could be counted in the same time. Of the forty-two remaining cases negative to the older method, antiformin was able to demonstrate the tubercle bacillus in 16·6 per cent. It is thus seen that the use of antiformin is a great advance on the older methods, both by increasing the percentage of positive sputa, and also by facilitating in all cases the discovery of the bacillus.

Antiformin finds further use, first outlined by its discoverer, in the treatment of sputum destined for animal injection, for thereby other organisms are destroyed and

sepsis avoided. For this purpose the residue must be washed free of the drug before injection.

It is further of value in the subsequent search for tubercle bacilli in the glands of the injeeted animal, the macerated gland pulp being thereby dissolved away and the bacilli left intaet.

The Method of Ellermann and Erlandsen

This method was introduced in the same year as the antiformin mcthod, and in some hands has given even more notable results than the latter. Thus Matson among cases negative to ordinary sputum examination, found 21 per cent. positive by this method as against 9 per cent. by Uhlenhuth's method and 14 per cent. by Schulte's modification of it. This was for Ziehl-positive organisms (see next section), but Ellcrmann and Erlandsen's method also gave the best results with the Much type of organism. The only disadvantage in the method is the necessary delay of 24–48 hours in the proeess.

Process. 1. To 1 volume of sputum (10–15 e.c.) add $\frac{1}{2}$ volume of 0·6 per cent. sodium carbonate solution. (Schneider recommends 5 c.c. of sputum with 25 c.c. of the diluent.)

2. Incubate for 24 hours.
3. Decant, centrifuge, and again deeant.
4. Add 2 to 4 parts of 0·25 per cent. eaustie soda to 1 part of residue.
5. Warm and shake, eentrifuge, and examine residue.

STAINING OF TUBERCLE BACILLI

Ziehl-Neelsen Staining

The time-honoured earbol-fuchsin method may here receive short description as an introduetion to more recent work.

Pick out a cheesy or muco-purulent particle of

sputum, and spread between two slides by pressing these together and afterwards sliding them apart. If an examination of the cellular elements is also demanded, the films should be separately spread with a platinum loop. Dry in the air, and fix by passing three times through a Bunsen flame. Cover the specimen with the freshly filtered carbol-fuchsin solution (carbol fuchsin 1, absolute alcohol 10, carbolic acid 5, and distilled water to 100), and heat to steaming, but not to bubbling, over a flame. Blot off the excess of the reagent, and decolorise in 33 per cent. nitric acid, or 25 per cent. sulphuric acid. Wash in 60 per cent. alcohol, or in methylated spirits, till almost colourless, wash out in water, and counterstain with a watery, or alkaline, solution of methylene blue; wash, dry and examine with the microscope.

S. Roodhouse Gloyne obtained the following results by this method among 100 unselected cases from the wards of the City of London Hospital for Diseases of the Chest :—

	Early and doubtful cases.	One lung affected.	Both lungs affected.
Tubercle bacilli found . .	4	29	28
,, ,, not found . .	17	9	2
Average number of sputum examinations made . . .	6	3	2

Much Staining

It was shown by Michaelides and Much in the year 1907 that there exist tubercle bacilli which have lost their acid-fast properties while retaining their virulence. Klebs in the same year found similar organisms in the examination of tubercular testicles, and also in cultures, and looked upon them as adolescent forms. Much described two varieties, a somewhat granular rod-shaped organism, and a form showing nothing but granules either irregularly heaped or isolated; they retain the

power of staining by Gram's method though not by Ziehl-Neelson. He found them in cases of cold abscess; their identity was proved by intraperitoneal injection into guinea-pigs, when after three days they recovered their acid-fast properties, and later gave rise to tuberculosis.

Wirths also succeeded in reproducing acid-fast organisms from the Much granules after the manner described, but Böhm rightly points out that in these experiments the injected material cannot be so closely scrutinised as to exclude the possible presence of a few acid-fast bacilli capable of multiplying and giving rise to tuberculosis. Regarding the Much granules as degeneration products, he is doubtful whether the tubercle bacillus can be reproduced from them.

Wirths further claimed that by the injection of acid-fast bacilli into the peritoneal cavity of a guinea-pig he caused them to lose the power of staining with Ziehl-Neelsen though remaining Gram-positive. This change was found to occur especially in phagocytosed bacilli, suggesting the possibility that their presence in cold abscesses depends on the action of digestive enzymes formed from dead lymphocytes on the fatty capsule.

R. C. Matson also supports the theory of a fat-splitting enzyme derived from lymphocytes being responsible for the occurrence of Ziehl-negative types of bacillus. He found the organisms in cases of chronic type complicated by chronic bronchitis, bronchiectasis, and emphysema, and hazards the suggestion that with an acute exacerbation the acid-fast properties return.

Frequency of Much-staining bacilli. As regards the frequency of occurrence of tubercle bacilli which have lost their acid-fast properties and only retain the power of staining with Gram or Gram-Much (see next page), various opinions are held. Röpke, among many hundreds of sputum examinations, found these

organisms in 12 per cent. Beyer among 52 sputums found 34 stain with both Ziehl and Gram-Much, 14 only with the latter, and 4 negative to both. Berka found 30 per cent. Ziehl-negative and Gram-Much positive in a large number of sputums. Rosenblat, on the other hand, found only 1 such example among 80 sputums. Weiss described 8 cases of caseous glands in which Ziehl-negative bacilli were found, and in 3 of these cases their virulence was proved by animal experiment.

It is interesting to observe that Wolff-Eisner pointed out this loss of staining power also in dead and broken bacilli supplied by different firms for opsonic or agglutination experiments.

Gram–Much II. Three modifications of Gram's stain were introduced by Much for the identification of the Ziehl-negative bacillus. Of these the second, known as Gram-Much II, seems to give the best results.

1. Stain in methyl violet (10 c.c. absolute alcohol are saturated with methyl violet and 100 c.c. of 2 per cent. phenol added) for 24 hours at 37° C., or 48 hours at room temperature, or a short while at boiling point.
2. Iodine solution (iodine and pot. iod.) 1–5 minutes.
3. 5 per cent. nitric acid 1 minute. (Böhm finds this too weak, and recommends 30 per cent. nitric acid for 1 minute.)
4. 3 per cent. hydrochloric acid for 10 seconds.
5. Acetone alcohol (equal parts acetone and absolute alcohol).

In the search for Much granules care must be taken that cocci, very commonly present in sputum, are not mistaken for these. This is unlikely to occur if antiformin is used, and the method is practically worthless without; but in that case carbon particles are apt to deposit and give rise to error. To avoid this Beyer recommends the use of ligroin, a light hydrocarbon oil, introduced for this purpose by Lange and Nietsche after

the trial of xylol, benzol, and other liquids. It acts by carrying up the bacilli, attracted by the action on their fatty envelopes, so that they are held at the junction of the two fluids while the heavier carbon and other particles fall to the ground.

Conclusion. It seems clear that before the sputum can be said with certainty to be free of tubercle-bacilli the Much-granules must be looked for. The routine of sputum examination, then, needs to be :—

1. Treat with antiformin or other sedimentation method.
2. Stain with Ziehl-Neelsen method.
3. Stain by Gram-Much method where acid-fast bacilli fail to appear.

Other acid-fast bacilli. Before leaving the subject of the tubercle bacillus in sputum, it seems necessary to add a word about other acid-fast bacilli liable to be met therein. These consist mainly of the smegma bacillus, which may be present in nasal cavities, teeth, or tongue; certain acid-fast bacilli found in gangrene of the lung and in bronchiectatic cavities; and the psuedo-tubercle bacillus of milk and butter. Fat needles as a source of error have already been referred to (p. 196).

These various organisms are possible though improbable finds in a sputum examination, and their presence might well lead to error.

Pappenheim distinguishes smegma bacilli by their limited power of retaining the fuchsin against decolorisation with alcohol, and this seems characteristic of the group. He immerses the specimen three to five times in a solution of absolute alcohol 100 parts, corallin 1 part, methylene blue to saturation, and glycerine 20 parts. After washing, drying, and mounting, the specimen shows tubercle bacilli still red, but smegma bacilli blue. Bandelier and Röpke recommend shaking up the sputum with sterile broth and incubating; if there is a distinct increase in the acid-fast organisms these are pseudo-tubercle bacilli, since Köch's bacilli will not

multiply under these conditions. Even animal experiment presents difficulties, for some of these acid-fast organisms, as those from butter, will cause nodular swellings in an injected guinea-pig, though under these circumstances the animal fails to react to tuberculin. The smegma bacillus is negative to animal experiment.

It is obvious that even the presence of an acid-fast bacillus in the sputum must be viewed with enlightened scepticism in cases where the clinical and other findings are not in accord with a diagnosis of tubercle.

Further points. In the search of the sputum for tubercle bacilli two further points need emphasis. Firstly, in a negative case it is necessary to examine the sputum on many occasions, perhaps ten to twenty, before tubercle bacilli can be said to be absent; it not infrequently happens that many negative are followed at last by a positive find. Secondly, as already insisted, it is only a positive result which is of value in sputum examination, and no number of negative results can exclude the presence of phthisis. Mucoid expectoration is not to be rejected as useless; it may contain bacilli in considerable numbers. Finally, it is worth remembering that in cases where no sputum was present C. A. Blume was able to find tubercle bacilli in mucus mopped from the laryngeal region, just as Holt achieved success by a somewhat similar procedure in children (see p. 291).

ANIMAL EXPERIMENT

A further method of testing the sputum for tubercle bacilli when these cannot be found by staining methods, especially in cases where the albumin reaction (p. 203), or a cytological examination (p. 207) suggests their presence, has already been foreshadowed under the heading of the antiformin method. Formerly the only animal test depended on the development of tuberculosis, and to exclude this it was necessary to wait some six or eight

weeks. Then Lydia Rabinowitsch-Kémpner suggested examination for tubercle bacilli, after a period of three or four weeks, in the glands neighbouring the place of injection. Bloch found that in this way cases might be missed, and in 1907 devised a method by which growth of bacilli was fostered and their discovery made more certain. This consisted in bruising the inguinal glands between the finger and thumb at the time of the injection; as a result of this the glands became more rapidly diseased, and tubercle bacilli could be demonstrated in them after nine or ten days. The search for bacilli is greatly aided by the use of antiformin to dissolve out the macerated gland pulp. Morton achieves a similar result by giving the animal a massive dose of X-rays before or after inoculation. This lowers the resistance to such a degree that a diagnosis of tuberculosis can be achieved within eight or ten days. Such a shortening of the time interval, by four to six weeks, is likely to bring these methods more into prominence in the future, the long delay under the older method being practically prohibitive.

THE ALBUMIN REACTION

The presence of albumin in the sputum, first demonstrated by Biermer in 1855, was not studied in its relationship to tuberculosis before the investigation of Roger and Lévy-Valensi in 1909. These observers found albumin present in cases of pneumonia, passive congestion and œdema of the lung, and in pulmonary tuberculosis, but never in cases of simple acute and chronic bronchitis. They thereupon claimed that its absence at two examinations should suffice to exclude phthisis in doubtful cases. Dieudonné found its quantity increased in exacerbations of phthisis, and extolled its value in separating mere bronchitic from tubercular sputum in these cases; and Geeraerd agrees that its disappearance in cases where it was formerly present is

evidence of complete cure. Kauffmann finds albumin in cases of active phthisis, and thinks that in doubtful cases its presence denotes active disease.

In spite of discrepant results obtained by certain other observers not here quoted, there appears to have been general agreement that albumin is present with fair constancy in active phthisis but also in certain other diseases, and that it is absent in all or nearly all cases of bronchitis. Lesieur, who depended on the nitric acid test, found that all sputa containing tubercle bacilli gave a positive albumin reaction, and considered it futile to search for these organisms in a non-albuminous specimen. With this dictum Ritter is in agreement, but remarks that the amount of albumin bears no relationship to the richness of the sputum in tubercle bacilli. Some specimens with massive albumin only showed a few bacilli to microscopic examination; others with only a trace yet revealed numerous tubercle bacilli in each field. Ritter derived the following conclusions from his experience among 108 cases. " The positive albumin reaction is a sure indication of an inflammatory invasion of the pulmonary parenchyma which may be tuberculous, pneumonic, or congestive, and the reaction is always negative when the inflammatory process has not affected the substance of the lung, as in acute and chronic bronchitis and asthma; hence the reaction is of most importance in those cases in which the pulmonary infection is not yet manifest, and the differential diagnosis lies between tuberculosis and simple bronchial catarrh."

The whole number of cases quoted in the literature up to the present has not amounted to a very high figure. But Ridge and Treadgold were able to make personal observations on no fewer than 2,164 cases, a number as large as all other recorded cases put together. Of these the first 2,000, were tested by the nitric acid test, a much less delicate test than that of acidulating and boiling

which was applied to the remaining 164. They recommend the following technique :—

Technique. The sputum for examination must be coughed up deep from the lungs, and contaminated as little as may be with buccal secretion and naso-pharyngeal mucus. It must be examined fresh, or not more than six hours old in hot weather, though in cold weather it will keep twenty-four hours before fermentation arises. Decomposed secretions will often give a reaction simulating albumin. The sputum is inspected in thin layer on a dark surface and all clear mucus removed as irrelevant. The remainder is shaken up till homogeneous with four times its volume of normal saline solution, rendered just acid with a few drops of 3 per cent. acetic acid and filtered through moistened filter paper. Only albumin and globulin appear in the filtrate, which is collected in a test-tube, and the top layer boiled in the usual manner.

Results. The results among the 164 cases so treated are made clear in the following table :—

Group 1. *Cases with Albumin.*

Phthisis with tubercle bacilli in sputum	92
Clinical phthisis without tubercle bacilli	20
Bronchiectasis	6
Pulmonary œdema in heart disease	5
Lobar pneumonia	4
Neoplasm of lung	1
Aneurysm	1
Influenzal broncho-pneumonia	1
Pulmonary œdema in chronic nephritis	1
Total	131

Group 2. *Cases without Albumin.*

Bronchitis	25
Bronchiectasis	2
Simple laryngitis	1
Doubtful phthisis	4
Phthisis with tubercle bacilli in sputum	1
Total	33

Further details show that there were in all 93 cases of phthisis with tubercle bacilli in the sputum, and of these 92, or 98·9 per cent., were positive, and 1 failed to a single examination and was then lost sight of. Among the 2,000 cases examined by the nitric acid test 96·4 per cent. of cases with tubercle bacilli in the sputum gave albumin, a divergence due, in all probability, to the lesser delicacy of the test employed. The remainder of this group are all cases in which some disturbance of the lung parenchyma itself might be expected to be present, and this is, indeed, the inference which Ridge and Treadgold draw from their observations. They regard the presence of albumin as evidence of alveolitis, and this opinion appears to be borne out by their observation of the presence of alveolar cells in sputum giving the albumin reaction (see pp. 207, 208). In bronchiectasis, they point out, albumin may be present or absent according to whether the dilated tubes are shut in by thick fibrous tissue or not. Group 2 contains cases whose sputum was, with the important exception of the four cases of doubtful phthisis included, of purely bronchitic origin.

Conclusions. The conclusions drawn by the authors from the investigation outlined above are stated by them as follows :—

" 1. Practically all cases of active pulmonary tuberculosis contain albumin in the sputum.

" 2. A negative examination for albumin on three successive occasions, in cases where tubercle bacilli are also absent, is strong evidence against active tuberculosis.

" 3. The presence of albumin in doubtful early cases of pulmonary tuberculosis helps to support this diagnosis.

" 4. The test is of considerable value in cases of chronic tuberculosis and emphysema as evidence of active disease."

The writer, while agreeing in the main with these conclusions, would be inclined, on the whole, to lay more stress on a positive and less on a negative result. In a doubtful early case the diseases other than tuberculosis where albumin may be present are readily excluded, and the discovery of albumin becomes evidence of real value. Where, on the other hand, albumin is absent it must be borne in mind that in quite early phthisis no real lung sputum may exist, and that presented for examination may come from the naso-pharynx or bronchial tubes. The test is especially of value, in the writer's opinion, under two conditions—where the activity of old disease known to have been tubercular is in question; and where it has to be decided in an apical catarrh of doubtful causation, whether this is purely bronchitic or whether the parenchyma of the lung is also involved.

CYTOLOGY OF SPUTUM

Attempts have been made from time to time, though in but half-hearted fashion, to discover evidence for or against tubercle in the cytological formation of the sputum. Thus Wolff-Eisner expressed the opinion in 1907 that a differential count of the sputum cells showed, in tuberculosis, a very large preponderance of 'lymphocytes,' and this even where a mixed infection was present, and notwithstanding contamination with nose, mouth, and bronchial secretions. He recommended the method as a means, at worst, of calling attention to those sputa in which the tubercle bacillus was likely to be discovered, the only condition giving a similar appearance being whooping-cough. While not denying a preponderance of mononuclear cells in phthisis, observers of the French school have fallen foul of the word 'lymphocyte' applied to these. Bezançon and De Jong regard these cells as being, in the main, alveolar in

origin, and cite strong evidence in favour of this. Ridge and Treadgold have devoted a considerable amount of attention to the subject, and agree with the conclusions of French observers as to the alveolar origin of the mononuclear cells. The staining method they advocate is that of Bezançon and De Jong.

Technique. A film is made on a clean slide, fixed by immersion for two seconds in 1 per cent. chromic acid, washed, and stained for two and a half to three minutes in undiluted polychrome methylene blue of Unna, differentiated with 90 per cent. alcohol, washed, dried, and mounted. By this means the mucus becomes violet-red to artificial light, and the sero-albuminous exudation appears as large violet-blue drops.

Results. They divide the cells into three classes—small, medium, and large—and appear to find their proportional relationship of some value in prognosis. They suggest, moreover, that these cells are responsible for, or bear close relationship to, the presence of albumin in the sputum, the two tests running on closely parallel lines. Thus among cases with albumin 'plus' on p. 205, all contained alveolar cells, and in about 84 per cent. these were present in considerable numbers; whereas among cases where no albumin was discoverable the proportion with a large alveolar count was reduced to 28 per cent. They lay stress on the occurrence of nuclear degeneration, also, as evidence of phthisis, and describe a 'dusty' appearance of the nuclear network which they find characteristic of tuberculosis, but also of bronchiectasis. They find it to increase in proportion to the amount of lung tissue involved, occurring in 26 per cent. in Stage 1, 50 per cent. in Stage II, and 70 per cent. in Stage III.

Conclusions. From all this it appears clear that information of diagnostic value is obtainable from the microscopic examination of sputum, over and above

mere presence or absence of the tubercle bacillus. In addition to bare enumeration of cells, the appearance and staining of these are not without importance, though it must be admitted that the method is as yet not sufficiently well known or tested to render it suitable for current use. This is especially the case inasmuch as the albumin reaction seems to supply us with a rough-and-ready test of the mere presence of alveolar cells—the hall-mark of an alveolitis. The cytology of sputum must stand acknowledged then, for the present, as a hopeful field, but one so little explored as to lack the confirmation of results which only accumulated research can supply.

OTHER TESTS

COMPLEMENT FIXATION

This method, the tubercular analogue of the Wassermann reaction in syphilis, can never aspire to the worth of the latter for a very obvious reason. In the diagnosis of syphilis we look only for the answer 'yes' or 'no'—either the patient has got it or he has not, a very definite point to determine; with tuberculosis, on the other hand, the question is commonly one of 'more' or 'less,' since tuberculous infection is practically omnipresent. What we require, therefore, is a reaction which can separate the 'tuberculous sick' from the 'tuberculous healthy,' and the ability of the complement-fixation method to accomplish this task may be judged from the results to be presently set forth.

But before we inquire into the application of this method, it would be well to state shortly what is meant by 'fixation' or 'deviation of complement.' Certain proteid substances, which are generally spoken of as 'antigens,' and include the endoplasm of many bacteria, when introduced into the tissues of an animal have the power of exciting an 'immunity' reaction with the formation of specific 'antibodies.' Antibody tends to unite with, and to neutralise, its corresponding antigen, but this it can only do, with certain species of antigen, in the presence of a third body, present in fresh blood and spoken of as 'complement.' Hence if antigen, antibody, and complement are brought together in a mixture, the absorption or 'fixation' of complement—that is, its

disappearance in the free state—becomes an indication of the union of antigen and antibody, and thus of their specificity for one another. Fixation of complement can accordingly be used as a test for an antigen, if a known antibody is supplied, or, more commonly, as in the reaction to be described, for specific antibodies in the presence of a known antigen. For technical details of the reaction the reader is directed to the original articles quoted in the following text, reference to which will be found in the Bibliography.

In 1903, Bordet and Gengou demonstrated the presence, in the serum of tuberculous animals, of antibodies capable of fixing complement in the presence of tubercle bacilli. Wassermann and Bruck in 1906, after a series of experiments, announced that the sera of tuberculous patients who had been treated with tuberculin were capable of fixing complement in the presence of tuberculin. Citron soon after demonstrated the presence of this 'antituberculin' in the sera of tuberculous patients who had received no tuberculin treatment, and this result received confirmation at the hands of other workers. Thus Wolff and Mühsam obtained as many as 78 positive results among 105 cases of pulmonary tuberculosis, and Cohn 15 out of 57; none of these patients had been treated with tuberculin injections. But the complement fixation reaction as carried out by these workers, with some variety of tuberculin as the antigen, was found to be but partially specific, a large number of non-tuberculous patients reacting, and particularly all cases of syphilis.

Besredka's antigen. In 1913 Besredka introduced a special antigen prepared from growths of tubercle bacilli in a liquid medium composed of veal broth, containing the white and yolk of hen's eggs. No peptone, glycerin, or salts were employed; after three or four weeks' growth, the culture was heated to 115° C., and

filtered free of tubercle bacilli, the resulting broth being of sufficient strength to kill a tuberculous guinea-pig in a dose of 1·5 to 2 c.c. With the use of this antigen the following results were obtained.

Besredka and Manoukhine (1914), testing 750 persons sent to hospital with a view to a Wassermann reaction, found 69, or 9·2 per cent., positive to his tubercular antigen; 16, or 2·1 per cent., giving a 'partial' reaction, and 665, or 88·7 per cent., a negative result. Of the 69 positive cases, 53 were submitted to clinical examination, and 41 were found to be definitely tuberculous, and all the remainder suspicious with the exception of 4 cases; 51 among them gave a positive Wassermann for syphilis; among the 665 'negative' cases, 38 per cent. gave a positive Wassermann.

Among a further 150 cases examined by Besredka and Manoukhine, 43 non-tuberculous cases were all negative, and 107 tuberculous cases were positive with a few exceptions, mostly in moribund patients. They summed up their results as follows. "In the first stage of tuberculosis, the fixation reaction is always positive; in the second stage, the reaction is positive in the great majority of cases; in the third stage, the reaction is often partial or negative; in this latter case its failure is generally an indication of the near approach of a fatal issue."

Others working with Besredka's antigen have obtained somewhat different results, particularly as regards the appearance of a positive reaction in the non-tuberculous, and especially in syphilitics. Thus Inman among 100 hospital cases regarded as non-tuberculous obtained 24 per cent. positive results, while all the syphilitic cases giving a positive 'Wassermann' reacted also to the tubercular antigen. He pointed out that an ordinary Wassermann must be done in all cases, if this antigen is to be of any practical use in diagnosis. His tubercu-

lous cases, all with tubercle bacilli in the sputum, reacted to the number of 95 per cent.; the 5 negative cases were all of under one year's duration. He found that with a 32-fold dilution of the serum 48 per cent. of the tuberculous still reacted, while the non-tuberculous all gave negative results. He summed up his results as follows: "Repeated positive reactions, especially with a 32-fold serum dilution, in the absence of a positive Wassermann reaction, indicate the presence of an active tuberculous lesion. Repeated negative results indicate the absence of an active tuberculous lesion, if cases of under twelve months duration be excepted."

Bronfenbrenner, also using Besredka's antigen, obtained 93·8 per cent. positive reactions in the actively tuberculous; but positive results were also present in 24 per cent. of syphilitics, and in 8 per cent. of his healthy controls.

Polyvalent antigen. Better results than these were achieved by the 'polyvalent' antigen employed by Craig. This antigen is prepared from tubercle bacilli grown in a liquid medium of alkaline broth containing egg white and egg yolk. After a suitable growth has appeared an equal quantity of 95 per cent. alcohol is added, the mixture is shaken, incubated, again shaken, and finally filtered. Filtrates from several different stains of tubercle bacilli are mixed to form the antigen. Of 166 cases of pulmonary tuberculosis tested with this antigen, 142, or 85·5 per cent., were positive; among these 'clinically active' cases reacted to the extent of 96·2 per cent., 'clinically inactive' in 66·1 per cent. Among 'incipient' cases he obtained only 60 per cent. positive reactions; he found that the greater the amount of lung involvement the greater the percentage that gave a positive result. Among 250 non-tuberculous cases, 150 of whom were syphilitics, only 2 or 3 per cent. reacted. Among a further 150 syphilitics, all giving a

positive 'Wassermann,' not one reacted positive to the tubercular antigen. Moreover, 150 healthy controls all gave a negative result.

The weak points of his results lie, undoubtedly, in the low percentage of reactions among incipient cases, and in the large number of clinically inactive cases which present a positive result. He claims that the results are practically as good as those obtained with the Wassermann test in syphilis, and contends "that a positive result with the complement fixation test described indicates the presence of active tuberculous infection, even though the disease may be clinically inactive, and that as long as the test remains positive the patient cannot be said to be cured."

Dead tubercle bacilli as antigen. Dudgeon, Meek, and Weir obtained somewhat similar results to those of Craig with an antigen prepared from dead stock tubercle bacilli. Of 102 cases of pulmonary tuberculosis, mostly afebrile sanatorium patients, 84 per cent. gave a positive reaction; among 19 patients with quiescent disease, many of whom had been free of symptoms for years and were in excellent health, no fewer than 14, or 74 per cent., reacted positive; 9 controls were all negative, though they lived in daily close communion with the tuberculous patients. Here again the striking reactivity in arrested disease greatly detracts from the value of the results.

Living tubercle bacilli as antigen. Radcliffe, and also McIntosh and Fildes, have obtained good results from the use, as antigen, of a simple emulsion of living tubercle bacilli grown on Dorset's egg medium. The latter workers, among hospital cases of proved tuberculous nature, obtained the following results :—

Phthisis	43 cases.	33 positive,	or	76 %
Surgical tuberculosis (other than glandular) . .	26 ,,	21	,,	80·7 %
Tuberculous glands . .	16 ,,	6	,,	37·5 %

Their 87 controls, mostly patients suffering with other diseases, were all negative except three, two of which were leprosy, and one Addison's disease; 18 syphilitic cases failed to react.

Radcliffe's sanatorium results are summed up in the following table :—

	Stages (Turban).		Positive.	Negative.
Phthisis with tubercle bacilli in sputum.	I.	91 cases.	79 (88·6 %)	12
	II.	260 ,,	233 (89·6 %)	27
	III.	116 ,,	92 (79·3 %)	24
	Total	467 cases.	404 (86·5 %)	63

Among 52 healthy people tested on 187 occasions he obtained nothing but negative reactions. The same result was obtained among patients suffering from various diseases, including malignant disease of various organs, but no mention is made of syphilis. The conclusions he bases on his results he sets forth as follows : " Taking into consideration the high percentage of positive results in cases of pulmonary tuberculosis (with tubercle bacilli present in the sputum), and the fairly definite conformity between the positive results and the ultimate diagnosis in suspected cases, a positive finding is of considerable value in establishing a diagnosis."

Results. When we come to review the various results outlined above we are struck with their similarity to those obtained by certain other immunity reactions, particularly the conjunctival tuberculin test. The difficulty in all these reactions is to achieve a delicacy sufficient for the detection of early disease, without thereby letting in the healthy at the other end of the scale. The results of the complement fixation test will be seen to vary very greatly according to the antigen employed, and undoubtedly considerable improvement has been achieved by the use of a more and more 'specifically comprehensive' antigen. Both the polyvalent antigen

of Craig and the emulsion of living tubercle bacilli employed by McIntosh, Fildes and Radcliffe, present a notable improvement on Besredka's method, and still more so on the use of the various tuberculins as antigen. The exclusion of reactions in the healthy and in syphilitics is a great move forward, but there still remain two striking elements of failure in the method at its present best. Firstly, a very serious proportion of early cases fail to react, and it is just among such cases that the demand for diagnostic assistance is likely to be made. Secondly, a positive result is obtained in all too large a proportion of arrested or quiet cases—the presence of 'anti-tuberculin' in the serum appears to be no criterion of present activity. Taken all in all it appears that the test, as used in its most modern form, is capable of supplying us with certain more or less useful probabilities.

Conclusions. A **positive reaction** in a case of doubtful disease with symptoms, appears to be good evidence that active tuberculous foci are present; in the absence of symptoms we may be only dealing with arrested or cured tuberculosis. If Besredka's antigen is used it is necessary to prove the absence of a Wassermann reaction to syphilis.

A **negative reaction** is of less value, on account of the recognised failure of the method in cases of early disease. In cases, however, where chest disease of doubtful nature has been present for over a year, a condition we hope to be highly problematical, a negative reaction appears to be some evidence of its non-tuberculous nature. But even here we must bear in mind the 10 to 20 per cent. tuberculous cases that fail to react in Stages II and III (Radcliffe), and its total failure in cases of advanced disease (Besredka), where the reacting power of the patient has failed.

TUBERCLE BACILLI IN THE BLOOD

The discovery of tubercle bacilli in the blood-stream seemed at first sight likely to supply valuable aid in the diagnosis of active disease. First described by Rosenberger in 1908 as occurring in every one of 125 cases of phthisis at all stages examined by him, it was naturally for a time discredited, but later appeared to be confirmed by Mendenhall and Petty (1909), Forsyth (1909), and others, and finally by Jensen and Lydia Rabinowitsch-Kempner (1910). Much of this earlier work, however, has been brought into discredit by the discovery in the tap water and distilled water used in these experiments of acid-fast rods very closely resembling tubercle bacilli (Brehm, Beitzke, Schern, and Dold). By careful technique it is possible to eliminate these rods, but there still remain acid-fast particles composed of cholesterin, lecithin, and the sheaths of red blood cells which occur in the blood, and also artifacts resembling acid-fast bacilli where the antiformin method is employed. Nevertheless, later experiments, where these errors have been so far as possible eliminated, still seem to show that tubercle bacilli are present in the blood in a definite large percentage of cases of phthisis and other forms of tuberculosis. True, the test of animal experiment has proved almost invariably negative (Anderson, Rumpf, Ravenel and Smith, Kessel, and others), though Lawrason Brown, Heise, and Petroff were able to record 3·5 per cent. positive inoculations among 84 cases of open lung tubercle.

But the failure of animal experiment is not, according to Klemperer, conclusive evidence of the absence of tubercle bacilli. He argues the matter as follows: Acid-fast rods are found microscopically, in small numbers, in the blood of a large proportion of consumptives.

Animal experiment shows that but few have *virulent* tubercle bacilli in the blood. But to infect a guinea-pig a certain number of bacilli of a certain virulence are needed, perhaps of greater virulence than the bacilli which survive the bactericidal power of the blood of the average case of phthisis possess. Since acid-fast rods are found microscopically only in the blood of tuberculous persons, and not in the healthy, and the negative animal test does not speak against their being tubercle bacilli, and since their frequent occurrence in the blood stream is supported by clinical and anatomical facts, we may, he holds, consider these acid-fast rods to be tubercle bacilli.

So far as the early diagnosis of tubercle is concerned, the detection of bacilli in the blood offers as yet no practical assistance; we await with interest the appearance of further developments in this direction.

PART II. CHILDREN

TUBERCULOSIS OF THORACIC GLANDS
HILUS TUBERCULOSIS

CONTENTS

INTRODUCTION

We possess, unfortunately, no English adjective the equivalent of the convenient 'ganglio-pulmonaire' of the French—a term which expresses in a word the essential features of tuberculosis in its earliest clinical stages in the child. For in the child, as in the adult, the seed is most commonly sown in the lung area: the resulting disease, however, tends to run a different course and presents a different clinical picture on account of the recency of the 'primary' infection and the prominence of the lymphatic structures at this end of life. True! apical phthisis of adult type may be met with in children of six or seven years upwards. Indeed, a chronic pulmonary tuberculosis with cavitation is even found in infancy, but this mainly concerns the morbid anatomist and seldom comes within reach of early diagnosis or treatment. As to apical phthisis of children, it is uncommon, as the writer has pointed out elsewhere. Among 1,165 cases of phthisis attending his clinic during the four years 1905–8 but 31, or 2·6 per cent., were children below the age of fifteen years, and the majority of these bordered upon the upper age limit.

In childhood, the course of the disease is generally as follows: Infection enters through the lung or by the bronchial mucous membrane, and is arrested in the glands. In young children the primary focus generally occurs in the lung, as was pointed out by Parrot and confirmed by the investigations of Küss and of Ghon; indeed, the X-rays will sometimes reveal this focus

together with a chain of diseased glands stretching from it to the lung root. The glands enlarge rapidly and caseate early at this age, and acute pressure symptoms may arise. In older children it is generally found that the lesion of entry has healed, but disease is left smouldering in the root glands. These, then, become, from the clinical standpoint, the primary focus of tubercular disease both of lung and of other parts in childhood; the infected area may lie dormant for years and again become active at some later time when resistance is lowered after bronchial catarrh or general illness. It may, on the other hand, never lead to clinical disease and subsequently heal. We speak, then, of 'Tuberculosis of Thoracic Glands' or 'Hilus Tuberculosis' as the earliest clinical stage of lung tubercle in childhood; the latter term, the modern equivalent of the 'bronchial phthisis' of old writers, comes nearer perhaps to the 'ganglio-pulmonaire' conception in that it does not pledge us to the glands alone, and this is better, since, even in early stages, a certain amount of lung infection is practically always demonstrable.

It has been established by the Vienna school, and abundantly confirmed from other quarters, that some 90 per cent. of town children have been infected with the tubercle bacillus by the time the age of ten or eleven years is reached (see Fig. 24). But in an investigation carried out a few years since by the writer in conjunction with W. Overend into "the clinical and radiological diagnosis of intrathoracic tuberculosis in children of school age," it further became clear that such 'infection' proceeds in almost all cases to the production of decided disease, a fact well recognised by the pathologist. Alike to clinical and to radiological examination, a very large proportion of the sixty-one children, between the ages of five and ten years, investigated showed manifest signs of tuberculous disease of gland,

or lung, or both. Nor was disease of necessity limited to small dimensions; in many a considerable amount of glandular and lung involvement was present with but little evidence of resulting ill-health. Thus it was clear that the mere presence of tuberculous changes did not necessarily call for treatment, nor even for any change of habits and environment in most cases. Indeed, in the absence of symptoms it appeared that such

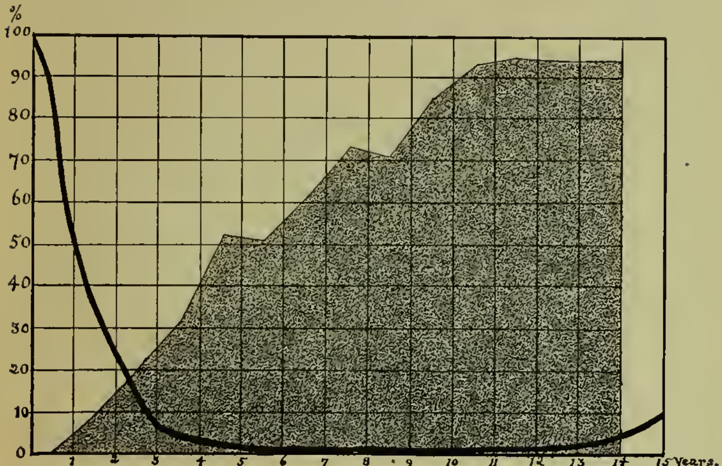


Fig. 24.—A Diagram of Age Incidence and Mortality in Tuberculosis: after Escherich (*Wien. med. Wochenschr.*, 1911, lxi. 115). The shaded area shows the incidence of disease in Vienna at different age periods; the heavy line indicates the percentage mortality.

infection and disease must be looked upon as an inevitable, and possibly a beneficent, accompaniment of communal life, and need give rise to no alarm unless evidence of ill-health appeared.

When, however, amongst the youthful denizens of crowded communities symptoms suggestive of tuberculosis manifest themselves, it is to the chest that we must turn, since it is from the thoracic glands, in nearly all cases, that the disease will spread elsewhere.

Still found them affeeted in 81 per cent. of tubereular children eoming to autopsy, Carr in 80 per eent.; Hamburger of Vienna, among 86 cases of localised tuberculosis, found the primary lesion in the bronchial glands in 85. Albrecht and Küss recorded similar experiences from Frankfort and Paris respectively. In a number of eases the mesenteric glands are also diseased, but they less often give rise to trouble than do those in the thorax.

There are two ways, apart from the appearance of distant foei of tubercle, in which the diseased thoraeie glands may give notiee of their presence—

(*a*) By acting as a centre of spread of disease into the lung.

(*b*) By enlarging so much as to press on neighbouring struetures.

It may be said at once that deeided pressure signs are uneommon. Moderate glandular enlargement is the rule, sufficient to interfere to a certain extent with such easily eompressible structures as veins, or to cause irritation of nerve-endings. But the text-book picture of enlarged chest glands with gross pressure signs and symptoms is culled from rare and marked eonditions and is, in the writer's experienee, by no means representative of familiar appearances. As Henoch shrewdly remarked, "The clinical descriptions which authors give of glandular enlargement have the look of having originated in the study and not at the bedside." Especially is this true of older children, in whom extreme enlargement of glandular structures is very decidedly rare. In infancy, to be sure, cases with marked pressure signs and symptoms do sometimes oceur and are sufficiently striking when they are met with. Nevertheless, it is remarkable, even in infancy, how often masses of easeous glands are revealed at autopsy without having given rise to any characteristic pressure symp-

toms during life. It is quite clear that considerable enlargement of thoracic glands can occur without such symptoms.

If pressure phenomena were more striking it would greatly help us in the diagnosis of thoracic gland disease at a really early stage—the problem which is now before us. When we consider, however, the striking mobility of the bronchial tree, the negative pressure within the thorax, and the readiness with which the lung recedes before any solid structure, we can hardly feel surprise that enlargement of these glands should give us so few pressure or other symptoms. Henoch refers to this in somewhat pessimistic utterance: "Can we, then, diagnose," he asks, "the condition of the bronchial glands during life by any definite symptoms? As far as my experience goes I must answer this question in the negative in the great majority of cases."

Matters have, fortunately, advanced very greatly since this remark was made, both in the direction of improved physical examination and also in our possession of radiological methods. Although in the very earliest stages active tuberculosis of thoracic glands may fail to give signs in either of these spheres of physical examination, it cannot be long before parasternal or paravertebral dulness, or glandular shadows on the plate present changes characteristic of tuberculous invasion. And, fortunately, these evidences come by no means too late, as a rule, for therapeutic measures in cases where such are needed. On the other hand, as already remarked, both glands and lung may be involved in a quiet tuberculous process of considerable amount, without any symptoms so striking as to arouse the alarm of parents. When symptoms do arise, however slight these may be, the case has passed into the category of tuberculosis requiring both present treatment, and also future care and prolonged vigilance.

It will be readily appreciated that, since the chest glands are numerous, and each group possesses different anatomical relationships, the symptoms and signs must necessarily vary somewhat according to the localisation of disease. On this account we seem faced with a very difficult problem when it is required to describe a clinical picture so various. But in practice this diversity is perhaps less striking than might, at first sight, be expected, since the intrathoracic glands stand in close physiological relationship one with another, and disease does not long remain confined to any single group.

It has seemed best to the writer to give, at the outset, a short description of the glands most commonly diseased, and their relationship to surrounding structures, following this with an outline of the manner in which tuberculosis may spread from them into the lung. A brief résumé of symptoms follows, in so far as these have a bearing on diagnosis, and more particular attention is paid to such prominent danger signals as cough, visible veins, and enlargement of manifest glands. Thereafter comes a short account of the normal chest in childhood, followed by a description of the physical signs of disease, with some estimate of the reliability of reputed signs in the diagnosis of glandular or pulmonary tubercle. Pressure signs, so far as these are not included under the usual physical signs, will then be set forth under the heading of the anatomical structures involved, and at the end of this section will be presented a brief illustration of the general aspects of tuberculous disease as it occurs in infancy, and as it is commonly met with in children of school age. Finally, separate chapters will be devoted to certain special tests, and diagnostic methods demanding particular knowledge and investigation—the X-rays, our most notable and promising ally; tuber-

culin; and the significance of temperature changes in childhood.

THE THORACIC GLANDS AND THEIR RELATIONSHIP

The intrathoracic glands can be conveniently divided into parietal and visceral: it is only with the more important groups of the latter that we need concern ourselves here. From the trachea downwards run a continuous chain of glands named for convenience according to their position the tracheal, tracheo-bronchial, bifurcation, and interbronchial or broncho-pulmonary. The last three of these groups play so important a rôle in thoracic glandular tuberculosis as to call for careful description.[1]

The tracheo-bronchial glands lie round the junction of the trachea and bronchus, mainly in front of these structures, whence they are often called pre-tracheo-bronchial. Those on the right side are most often diseased, and their close relationship with important structures renders them specially liable to produce pressure symptoms.

Relations of Right Pretracheo-bronchial Glands

In front. Superior vena cava and part of aortic arch.

Behind. Trachea, bronchus, and right vagus.

Above. Subclavian artery, and recurrent laryngeal nerve.

Below. Right branch of pulmonary artery and the vena azygos as it turns over the right bronchus.

To right. Upper lobe of lung.

To left. Aortic arch, trachea, right innominate artery.

[1] For a clear understanding of the position of these gland groups the reader is referred to the excellent illustrations at the end of Barety's book, for which see Bibliography.

The most important relationship of the left tracheo-bronchial glands is the recurrent laryngeal nerve which lies along their outer side at the beginning of its course.

The bifurcation glands are, in the writer's experience, those most often and most early diseased. They lie underneath the bifurcation of the trachea and especially under the right bronchus. In front is the pericardium, separating them from the right branch of the pulmonary artery; behind are the œsophagus, aorta, vena azygos, ramifications and anastomoses of the vagi, and the posterior borders of the lungs.

The broncho-pulmonary glands extend into the lungs up to the fourth division of the bronchi. They occupy the angles of division of the bronchi, and are hence named interbronchial by some writers. In this position they are in especially close relationship with branches of the pulmonary artery, since these also pass through the angle formed by the bronchi at their bifurcation. Of this group those belonging to the first division of the right bronchus are especially apt to be diseased in connexion with glands of the other groups already described.

Lines of Spread

A few words seem needed on the presumed manner of spread of the disease from the glands out into the lung, since this is not clear to cursory examination. The normal lymph flow in the lung is, of course, from the periphery inwards to the root, the upper and middle parts of the lung draining into the tracheo-bronchial glands, as was demonstrated by Ghon, and the middle and lower into the bifurcation glands, and thence also to the tracheo-bronchial glands; such flow soon becomes obstructed in certain areas when tuberculosis of the lymphatic glands arises. Blockage of the lymph chan-

nels then leads to their distension, and finally to a backward flow, either directly from incompetence of their valves, or indirectly through the free anastomosis of lymph channels in the lung whereby the lymph is drawn outwards into neighbouring systems.

In whichever way impelled the tubercle bacilli travel outward from the glands towards the periphery with a fan-shaped distribution, passing through the lymphatic walls as they go, and starting peribronchial inflammatory changes, and in some cases broncho-pneumonic processes in the surrounding lung. If these lesions heal, the resulting scars still further increase the obstruction, and so the disease passes outwards slowly or quickly, mainly in the tissue round the bronchi and vessels. Radiography seems to show that this invasion of the lungs may be, in some cases, in the nature of a simultaneous ‘ sowing ’ of bacilli throughout both, while in others it appears to proceed gradually or in stages (see pp. 123, 124). A similar process appears to occur in silicosis and other dust diseases, whence the resulting fibrosis tends to simulate tubercular disease when examined with the X-rays. In addition to retroimpulsion of lymph as a means of spread from tubercular glands into the lung, mention must be made of the close relationship of the tracheal glands to the lung apex itself, for it is not uncommon for such glands, when tubercular, to adhere at this point and to spread the disease by contiguity.

CLINICAL DIAGNOSIS

SYMPTOMS

These are of value in that they bring the patient to the physician, and tend to direct the attention of the latter into the right channel; they can of themselves never supply the means of diagnosis. Wasting and cough are the two most prominent symptoms, and a little separate attention may be usefully devoted to each of these individually. **Wasting** is an almost invariable complaint in children brought with tuberculosis, but children lose weight readily, and tuberculosis is by no means necessarily the cause. Nevertheless it is a frequent one in cases where gastro-intestinal symptoms are absent, and the weighing-machine is a good index of normal progress or the reverse. Shoemaker has pointed out how valuable from this point of view is the regular weighing of children, especially in schools, since all healthy children gain weight steadily, and failure to do so should at once lead to investigation.

Cough at the outset of tuberculosis is occasionally so slight as not to be noted; but if it is looked for it will be found that it practically always occurs, both at the first tubercular invasion, as Hamburger showed, and also with the exacerbation of disease in the glands, though it may be absent at intervals, and in infants altogether, as Schlossmann and also Holt have insisted. Often at the beginning it is the cough of bronchial catarrh, and nothing more; later it may become dry and hacking, or barking, or moist with a rattling of mucus. The

latter occurs especially in children of early age, in whom the cough may become spasmodic, when glandular masses are present, and may simulate whooping-cough very closely, even to the crowing inspiration and vomiting in some cases. The 'brassy' cough of laryngeal paralysis may, in rare cases, be present. Among older children in whom hilus tuberculosis tends to be chronic, and remains stationary or smouldering over months and years, the cough is commonly short and barking, but otherwise in no way characteristic. Cough, it must be borne in mind, is, in children, so frequently due to the almost ubiquitous catarrhs of school life that no great importance can be attached to it, in itself. "On the whole," remarked Fishberg, "my observations lead me to the conclusion, which is in agreement with Hamburger, that cough *per se* is not of great significance in the diagnosis of tuberculosis in children."

Together with wasting and cough are often associated certain other symptoms in varying proportion and degree; above all, night sweats and fever. **Night sweats** in children have by no means the significance that they bear in adults, and are comparatively common apart from tuberculosis. Czerny showed that their amount varies with the depth of sleep, being most marked when sleep is deepest. "To be of diagnostic significance," remarks Fishberg, "night sweats in children must appear during the second half of the night, and be so profuse as to soak through the bedclothes. Even in such cases they may not be pathognomonic of tuberculosis; the possibility must always be borne in mind that they may be of nervous origin, especially in older children." **Fever** may have been noted before the child is brought for examination, but if not it must be carefully looked for; the interpretation of temperature changes in childhood is open to so much misconception that the writer has elected to consider

the subject of fever under a separate heading, and to this the reader is referred (pp. 284, 289). **Chest pain** on deep breathing or with exercise is an occasional complaint in cases of hilus tuberculosis. Loss of appetite and **dyspepsia** may be symptoms of tuberculosis in children, as in adults; some reference to the wasting of chronic gastro-enteric catarrh will be found on page 259.

Finally, careful inquiry must be made as to **opportunities for infection**, since this bears a far higher importance in childhood than in later years. A case of open tuberculosis in the household is of special significance, and this question of contact must be kept clearly separate from that of **heredity** with which it is very apt to be complicated. The family history should, however, also be elicited, since hereditary vulnerability of tissue is a factor, though a less important one than opportunity for massive infection.

FULNESS OF SUPERFICIAL VEINS

This constitutes so common and important a pressure sign in connection with enlargement of intrathoracic glands as to demand some separate notice. Stoll found the veins abnormally visible in 92 of 173 tuberculous cases investigated by himself. The veins whose fulness should be noted are those over the chest wall, the anterior jugulars in the neck, and the veins over the temples. Not infrequently all these are visible together in the same case.

Chest veins. A thin and delicate skin causes the superficial veins to be abnormally visible, but in this case the condition will be general. The history, as a rule, helps little, since these veins commonly pass unnoticed, and when attention is called to them are presumed to have been always present. They are often most visible on the right side, but are generally double,

and their course is inwards towards the manubrium. They owe their presence to pressure on the right or left superior intercostal vein, or on the vena azygos major, into which the former opens, and are thus evidence of enlargement of tracheo-bronchial or of bifurcation glands (see pp. 227, 228). The vena azygos major receives blood from all the intercostal spaces save only the upper two or three on the left side, which are drained by the left superior intercostal. The enlarged radicles must represent a collateral circulation and not engorged venules, since in all cases, in the writer's experience, the flow is inwards towards the sternum and the internal mammary veins.

Fishberg recorded that 8 per cent. of children out of tuberculous households had enlargement of thoracic veins. After dividing the children into three groups, as a result of careful clinical examination, he noted that among those diagnosed as active tubercle 37·5 per cent. showed this sign, among those suspected of latent tubercle 25 per cent., while among the 'healthy' remainder only 1 per cent. exhibited dilatation of the veins over the chest.

The anterior jugular and temporal veins. These become distended where pressure is exerted on the superior vena cava, or innominate veins within the chest. The condition is often associated with fulness of chest veins, and may be brought about by enlargement of the same glandular group. For tuberculous tracheo-bronchial glands which obstruct the azygos are generally found, on oblique radioscopy, to bulge forward also towards the superior vena cava, in which case the fulness will occur on both sides, which is very commonly the case. It must be borne in mind, however, where pressure symptoms are in question, that tuberculosis of glands is seldom localised to a single group but soon involves a considerable chain by contiguity. The full

jugular generally fails to empty as it should on deep inspiration.

Spinal telangiectases. Attention has been directed from time to time to the spider-like dilated venules, so often to be seen round the spines of the upper dorsal vertebræ, and occasionally in other situations over the back, shoulders, and chest. Parkes Weber described these as present in 50 per cent. of healthy young adults. The writer examined 164 children at ages 12 and 13 years, with a few of 8 years, at school in a healthy London suburb, with regard to the incidence of spinal venules. He found them present altogether in 71 children, or 43·3 per cent.; in 16 cases they were noted as strongly marked, in 30 cases as slight, and in the remainder as merely "present." They were situated in most cases round the spines of the 7th cervical and 1st and 2nd dorsal vertebræ, but in a good number extended as low as the 3rd or even the 5th spinous process. In 4 cases telangiectases were spread over back, shoulders, chest, and arms, and in 3 over the cheeks. The chest veins were unduly visible in 20 (28 per cent.) of these cases, while among the 93 children where spinal venules were absent, only 9 (9·6 per cent.) showed fulness of chest veins. There is thus reason to believe that spinal telangiectases and enlargement of superficial thoracic veins tend to hang together, and are, perhaps, attributable to similar cause, namely to interference with the venous flow through the superior intercostal, or the large azygos veins, by enlarged or tuberculous glands.

Some evidence in support of this assumption emerges from a separate investigation carried out by the writer; among 24 children from tuberculous households examined for spinal venules, they were present in 41·7 per cent., while 22 children from healthy households in the same neighbourhood showed them in only 23 per

cent. Moreover, the venules were found to be present twice as often in children with manifest signs of tuberculosis, as among children with apparently normal chests. Thus the presence of spinal telangiectases seems to point, just as does fulness of chest veins, to a probable pressure origin within the chest, the commonest cause being, in either case, tuberculous enlargement of tracheo-bronchial glands. It must, however, not be overlooked, that in some cases, and especially where the condition is widespread, these telangiectases are only of a nævoid nature, and bear no relation to congestion. In any case their significance must not be exaggerated, and their diagnostic value may be fairly gauged by the fact of their presence in over 40 per cent. of healthy young people.

ENLARGEMENT OF PALPABLE GLANDS

In all cases where tubercular chest glands are suspected the condition of the manifest gland groups must be carefully investigated.

Neck glands. The value of the neck glands as a guide to diagnosis is largely dependent on the social position of the patient. Among children in provided schools some enlargement of neck glands is the rule, and is associated with such conditions as enlarged tonsils, adenoids, dental caries, and various skin inflammations the result of dirt and neglect. Moreover, such enlargement when it has become chronic often represents a subsequent tubercular invasion—in as many as 73 per cent. among cases investigated by Moore in Prof. Delépine's laboratory. All the sources of irritation mentioned above must be excluded before any significance can be attached to cervical lymphadenitis. When, however, this has been done a certain amount of evidence with regard to the chest glands may be derived from this source.

There is no doubt that enlargement of neck glands is a common accompaniment of disease of the intra-thoracic group: Löschner in forty-two autopsies on cases of tubercular tracheo-bronchial glands found but thirteen in which the neck glands were uninvolved. A good deal of importance attaches to the particular group affected. Thus the **supraclavicular glands** bear a significance which none of the upper groups attain. These have been shown by Baréty to receive lymph from the parietal pleura, and according to Bartels are in direct upward communication with the tracheo-bronchial glands themselves. They are not usually palpable in health, or at most are felt as fine seed-like structures just above the inner half of the clavicle. In the investigation on school children already referred to (p. 222), enlargement of these glands was found by the writer in no children with normal chests, while all the cases in which they were present showed evidence of tuberculous disease of long standing, generally with signs of tracheo-bronchial enlargement, and all but one were noted as being of poor or bad nutrition. They were enlarged on one side or both in altogether 22 per cent. of the children examined as to this point, and in greatest proportion among cases of prolonged exposure to tubercle infection. These results fall in with the writer's general clinical experience of tuberculosis in children. He finds enlargement of supraclavicular glands a fairly common accompaniment of parasternal dulness at all ages, not excluding infancy, and regards it, when present, as important evidence of intrathoracic tuberculosis of advanced grade.

Of less diagnostic value are glands in the **posterior triangles,** though the writer has found from experience that in infants and young children multiple shotty-glands on one or both sides are of decided significance where other causation, such as skin irritation, is absent,

and where the submaxillary glands are but little affected. Occasionally a tubercular scar gives evidence of the nature of cervical adenitis, though this is, of course, no evidence that tuberculosis of intrathoracic glands is also present. Most important of all is enlargement of the deep tracheal group below the thyroid gland, for in this case a chain of disease generally exists between them and the tracheo-bronchial glands. Retrosternal glands might occasionally be palpated at the suprasternal notch, but the writer has never yet succeeded in doing this during life.

The axillary glands are, like the inguinal, somewhat large in health. They are in communication with the lymphatics of the parietal pleura, hence they and also the intercostal glands may reflect diseases of lung and pleura whether such diseases are tubercular or otherwise. Nevertheless, the writer has not found them of much diagnostic value save in cases, generally in children of early age, where a general gland infection, presumably of vascular origin, occurs. As Baréty has remarked, enlargement of neck, axillary, inguinal, and mesenteric glands all together is sure evidence of intrathoracic glandular enlargement also. A few shotty intercostal glands are not infrequently to be found on one or both sides in cases of intrathoracic tuberculosis in infants.

Mesenteric glands should be felt for, and are most often palpable just to the right of the umbilicus, where they give a shotty sensation if pressed against the spinal column. Considering how commonly these glands are diseased at the same time as the bronchial group, it is remarkable how seldom they are to be felt. It is, indeed, difficult to be sure of their presence unless considerable enlargement has occurred. Tenderness in MacBurney's region is present in a certain number of cases.

THE NORMAL CHEST IN CHILDHOOD

Before describing the signs of disease it may be well to insert a short prelude on the normal chest and its characteristics. For the child's chest differs from that of the adult in many particulars, and its examination is always a more difficult task. In early childhood its small size and rounded contour tends to make localisation less easy, favours conduction of signs from one lung to the other, reduces the normal percussion resonance, so that slight shades of impairment are more difficult of detection, and heightens the importance of the lateral aspects, which present almost as large a surface as front or back.

The right apex phenomena, for details of which the reader is referred to page 55, are even more striking over the thin chest of the child, both back and front, than in the adult, and blowing breath sounds, conducted from the tubes, are not infrequently heard over both backs. Collapse is common, whether with or without catarrh, and may simulate the signs of consolidation, or of pleural effusion, according to its amount and completeness. Moreover, in young children investigation is often restricted to a serious extent by their intolerance or fretfulness; a suitable posture for examination is very difficult to maintain, and assistance from voice sounds or forced respirations are often lacking. Fortunately in this latter particular Nature has been very beneficent to the physician, since she has substituted 'puerile breathing' for the feebler breath sounds natural to the adult. The respiratory needs of the young child appear to be so inadequately provided for that a condition of slight dyspnœa is normal, and this, when observed, must not be mistaken for evidence of lung disease.

The older the child the more nearly does case of

examination approach that found in the adult. Indeed, at the age of ten or twelve years conditions are in some respects ideal, since all the advantages of a thin chest wall are added to a tolerance about equal to that of the adult. But even at this age, and especially below it, two important methods of examination fail of their accustomed reliability. Movement of the two sides of the chest cannot be relied upon as a sign in childhood, since semi-voluntary differences of expansion are not uncommon in health; worst of all, investigation of Krönig's isthmus (see p. 66) is so difficult of accomplishment in the child, owing to the smallness of the parts, that we are usually deprived of a method which otherwise would be of exceptional value in detection of the hilus tuberculosis of early years.

PHYSICAL SIGNS

THE FRONT OF THE THORAX

Inspection

The chest wall shares the general malnutrition so commonly present in tuberculosis; occasionally the long narrow thorax associated with the 'habitus phthisicus' is also present, a sign, in all probability, of recovered infantile tuberculosis (p. 20). A network of veins over the surface may be found (p. 232), the jugulars may appear full, and firm glands be palpable in the neck (p. 235), or in the supraclavicular fossæ (p. 236).

Percussion

In some cases 'contrast percussion' establishes no difference of note between the two sides. Nearly always, however, there is slight impairment over the right side, often more notable at the apex; this right-sided incidence is partly dependent on the prone-

ness to earlier disease of glands and lung on this side. Bythell, to radiological examination among 200 early cases, found the right root involved in 37·5 per cent., the left in 20·5 per cent., while in 42 per cent. there was early disease of both sides. Impairment on the right side is also probably due, in some cases, to pressure of diseased bifurcation glands on the right pulmonary

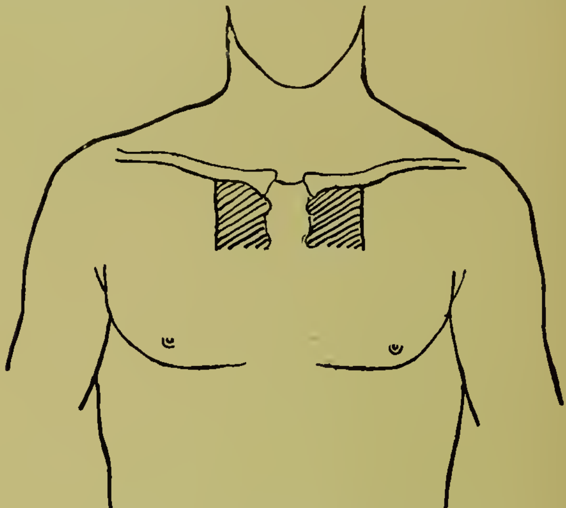


FIG. 25.—To illustrate parasternal dulness.

artery, whereby is produced deficient expansion of the right lung (see Paravertebral impairment, p. 246).

Parasternal dulness. While examining the front of the chest a careful marking out of the parasternal impairment must be made, after careful percussion from without inwards towards the centre. Normally there exists in children about 1 cm. of impairment on each side of the sternum, but in disease and swelling of the tracheo-bronchial glands this may be increased to 2 or 3 cm., or even to 4 or 5 cm., on one or both

sides. In such cases, as would be expected, it is not uncommon to find, in association with this, some fulness of chest veins from pressure on the azygos (p. 233), prominent jugulars from pressure on the vena cava superior (p. 233), and sometimes a secondary involvement of supraclavicular glands (p. 236).

Sternal percussion. This, in striking contrast to parasternal percussion, is, in the writer's experience, but rarely of value, since it requires very considerable enlargement of glands to produce recognisable changes. The junction of the manubrium with the body of the sternum, marked by the attachment of the second costal cartilage, corresponds, it will be remembered, with the bifurcation of the trachea. Enlargement of the tracheo-bronchial, lateral tracheal, or retrosternal glands may, in rare cases, give rise to dulness over the manubrium. It must be noted, however, that up to the age of six years, and in the writer's experience, at even later ages, the thymus gland gives rise to a certain amount of impairment. Percussion of the sternum is, at best, an unsatisfactory performance, since the bone is apt to vibrate as a whole, and thus to collect resonance from distant points. Nothing less than very definite impairment, accompanied by a heightened sense of resistance, can be taken as evidence of disease so far as sternal percussion is concerned. Such marked signs are but rarely found, since a considerable mass of glands is required to produce them. When they do occur, it may be expected, in addition, that tracheal breath and voice sounds will be strongly conducted, a sign never given with a large thymus, and also that wide parasternal dulness, a far more valuable proof, will also be present. A further point associated with the sternum is tenderness over the manubrium and the sterno-costal junction, but tenderness may exist in other parts of the chest also.

Auscultation

In a fairly early case of hilus tuberculosis in childhood it is not uncommon to find at an apex, particularly the right, broncho-vesicular breath sounds, with prolonged audibility of expiration, and an associated increase of vocal resonance. These signs must not be taken to imply infiltration of the lung, since they may equally occur with enlargement of glands alone. The breath sounds, under these conditions, may be either feeble, or appear unduly loud. Quite often, in cases where other signs denote the presence of hilus tuberculosis, no abnormality of breath sounds may be detectable.

Over the lower parts of the chest, particularly in the neighbourhood of the nipple, fine scattered crepitations are sometimes audible and that at early stages of the disease. They are generally but few in number, appear at the end of inspiration, and are generally of a dry, crackling, and perhaps somewhat consonating quality. They are not removed by cough or deep breathing, and are often heard in the same situation for months at a time. Stoll found these added sounds present in 47 among 137 cases. Miller and Woodruff found them on the left side of the chest in two-thirds of their cases; the writer thinks they are more often present on the right side; not infrequently they are audible on both. Whether these sounds are to be ascribed to atelectasis, to localised œdema, to pleurisy, to a true lung infiltration, or even in some cases to a dilatation of tubes, must often be matter of conjecture, and, doubtless, their nature differs in various cases. Against a tuberculous lesion as causation is the fact that they do not tend to increase or spread, nor to develop into areas of definite infiltration. In some cases they may be only 'tissue sounds' produced by pressure of the stethoscope — such tissue râles are common in tuberculous

children, but also occur in the healthy, and, when very markedly present, may be difficult to separate from sounds of intrathoracic production. Localised œdema is a very likely cause of crepitations, and similar signs, attributable to pulmonary engorgement and œdema, may be found at the bases in some cases of early phthisis in the adult, as was pointed out by Charles Fernet.

When the crepitations of lung infiltration are present, in cases where disease has at some spot reached the surface of the chest, these are generally more closely sown, and of moister nature, than are the sparse and scattered sounds described above. When disease has attained this comparatively advanced stage, these moist sounds often appear first over the front of the chest, whether below or above, and tend to spread quickly, as disease reaches the surface at other points. On some occasions the whole, or nearly the whole, of one side may be covered with signs before the surface of the other lung is involved; in others, the signs are more nearly simultaneous in their appearance on the two sides. In either case there is likely to be deep disease of roughly equal extent in both lungs, though it may be of more active nature in one than in the other.

Eustace Smith's Sign.—This sign is obtained by stethoscoping the manubrium, especially near its right border, and then getting the child to tilt his head backward as far as it will go. By so doing, enlarged tracheal or tracheo-bronchial glands are carried upwards and forwards, and may cause a venous hum by pressure on the superior vena cava, or left innominate. The value of the test is diminished by the fact that in young children with short necks, but less often at later ages, such a movement may almost certainly cause pressure on venous trunks even in the absence of enlarged glands. It must be borne in mind, moreover,

that a venous hum at the root of the neck is very commonly found in healthy children—in 66 per cent. of forty-eight boys examined by the writer on this point—and in some cases is also audible over the manubrium. The presence or not of this bruit must be noted before the head is extended.

Smith's murmur is very commonly obtained, as would be expected, in cases where enlargement of chest veins and jugulars is also present. A. G. Gibson found it in ten of fourteen such cases. It is of most significance in older children, among whom it is seldom present in health, and where it may indicate disease of pretracheo-bronchial or lateral tracheal glands, generally on the right side.

THE BACK OF THE THORAX

Inspection

Inspection may reveal the hairy back of scrofulosis (p. 261), and spinal telangiectases (p. 234) may be visible about the root of the neck.

Percussion

The reflex bands of impairment described on page 34 may be present, and give indication of active pulmonary disease. These are difficult of discovery in young children, but in older children may be readily demonstrated; if they are to be looked for, this investigation must precede all other examination, since percussion of the chest-wall will produce the reflex in conditions of health.

Following this procedure, 'contrast percussion' of the two sides must be carried out, when slight impairment may be discovered on one side, generally the right. This right-sided subresonance may depend, as in front, on a preponderance of disease in the right glands and

lung, or may be present in association with paravertebral dulness due to enlargement of bifurcation glands. In the latter case it is generally most marked above the midscapular level.

Paravertebral percussion. There was described by Ewart many years ago a paravertebral area of relative impairment in normal chests; this he designated the **oval interspinous dulness.** In adults it is not a very

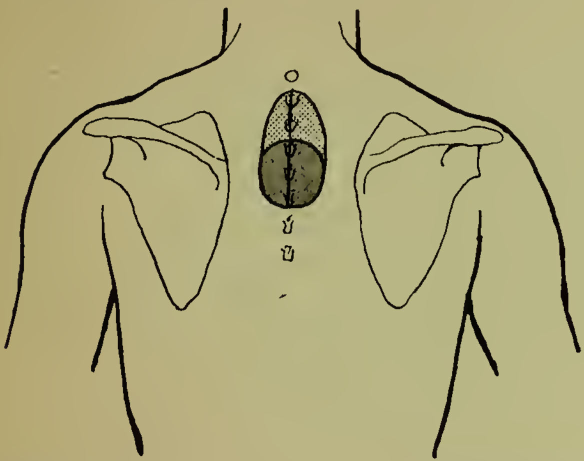


Fig. 26.—The normal outline of the 'Oval Interspinous dulness.'

striking feature, but in thin children it is a very definite entity, and extends out about an inch, or a little more, on each side of the middle line between the spinous processes of the 1st and the 5th dorsal vertebræ (Fig. 26). It is an enlargement of this paravertebral dulness which constituted one of the most important evidences of glandular enlargement within the thorax. In nearly all cases of paravertebral dulness of pathological extent it appears first on the right side; only at a later stage of chronic disease does it appear also on the left side, and then often to a less notable extent.

In an investigation (hitherto unpublished), which the writer carried out into the nature and explanation of this right-sided paravertebral impairment, he came to the conclusion that it was caused by pressure of the enlarged bifurcation glands on the right pulmonary artery. These glands, which lie below the bifurcation of the trachea, and tend to extend somewhat along the

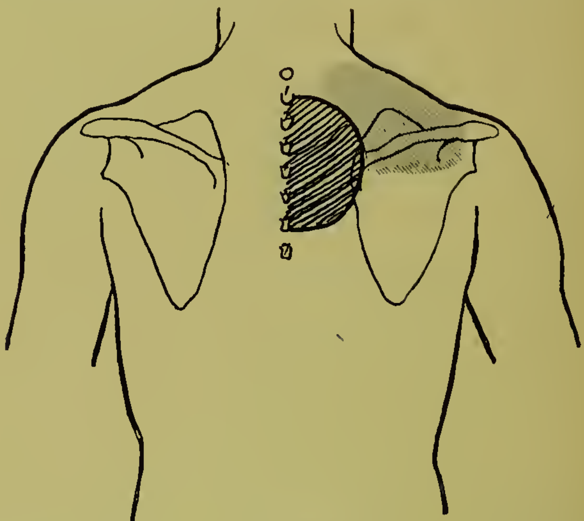


FIG. 27.—To illustrate right-sided paravertebral dulness, together with the apical impairment which generally accompanies it.

right bronchus, are generally earliest and most markedly diseased in cases of tuberculosis in children—not infrequently they form caseous masses of pigeon-egg size in cases where the other glands are but little affected. Immediately in front of them, with only the pericardium between, is the right branch of the pulmonary artery on its way out to the lung; the pulmonary vein lies at a lower level. It has been repeatedly demonstrated that obstruction of the pulmonary artery or its branches

leads to collapse of the lung tissue supplied, and it seems probable that firm pressure upon its trunk may lead to incomplete expansion of the lung, showing itself in a shrinkage from the root, leading to right-sided paravertebral impairment, and in a slight general percussion impairment over the lung, a common accompaniment of paravertebral dulness of glandular causation.

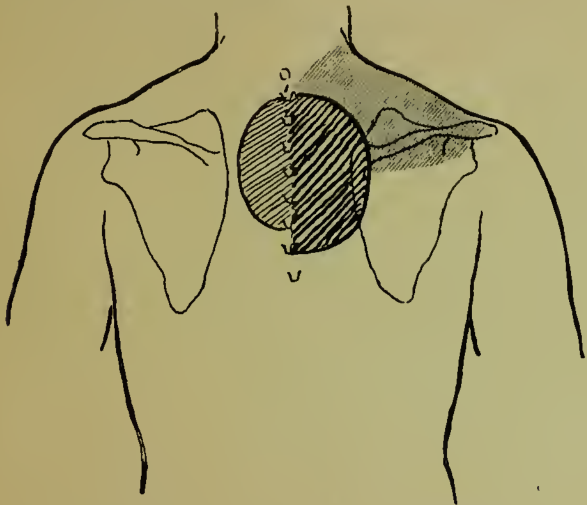


FIG. 28.—Double paravertebral dulness.

The writer has found marked right paravertebral dulness in cases where post-mortem examination appeared to exclude any other possible causation than the caseous bifurcation glands. The oval area of dulness found in these cases often extends down to the 6th or 7th vertebra, and reaches outwards some two or three inches from the spine. When paravertebral dulness becomes double, the left-sided area is probably due to pressure on branches of the pulmonary artery in the angles of division of the bronchi by enlarged contiguous broncho-pulmonary glands (p. 228). The left main branch of

the pulmonary artery is not liable to compression by glands as is the right branch.

Right paravertebral dulness is an early and valuable sign of enlargement of the intrathoracic glands, generally the bifurcation group, and it may for long be almost the sole evidence of disease, accompanied, as it generally is, by slight contrast percussion impairment over the right chest and back. It is, to be sure, in itself no clear evidence of tuberculosis, since glandular enlargement of other causation may cause it, and even when of tuberculous causation the disease may be arrested, or perhaps even obsolete.

Palpation

Since glandular and hilus tuberculosis is, for the most part, a bilateral disease, it may be expected that defective movement of one side is not a sign of very common occurrence. In this respect it stands in marked contrast to apical phthisis, a rare condition in children, where a localised lung infiltration soon leads to deficient expansion on the affected side. Only where one lung, often the right, is more notably attacked than the other, is this sign present with hilus tuberculosis. It must be borne in mind, however, that in childhood temporary irregularities of movement of more or less voluntary nature are common, whence much less reliance can be placed on this sign in children than in adults.

Auscultation

In hilus tuberculosis accompanied by considerable glandular enlargement, loud blowing breath sounds are often heard at the apex behind, just as they may be in front. Their presence in the paravertebral region is only a reflexion of the spinal conduction to be presently described under the heading of Spinal Signs (p. 251). In

this connection it must be borne in mind that conduction from the air tubes to the surface is far greater over the thin chests of children than in adults. This conduction is especially marked in the interscapular region, and more so on the right side, so that blowing quality of breath sounds, and strong vocal resonance, are found here in conditions of health. It is, consequently, very difficult to decide what value attaches to breath and voice sounds in this region, and it is safer to discount these signs unless they are very definite, and are substantiated by other evidence.

Hilus tuberculosis, be it noted, is often present without any change of breath sounds at the apex or elsewhere. Grancher and his pupils described as the "first stage" of pulmonary tuberculosis in children an alteration, generally a weakening, of the breath sounds at the apex, accompanied later by a slight bronchophony, and later still by percussion impairment. The writer has not found weak breath sounds common, whether at the apex or in the interscapular region. If found, their permanence must be established by repeated examination, since temporary changes of this nature are common over the lungs of healthy children. When they occur they will probably denote some bronchial obstruction from glandular pressure. In quite young children collapse of a whole lobe, or lung, may occur in tuberculosis, and be due to pressure on a bronchus, but it may also occur without such pressure. Bronchial pressure may also lead to a fixed sibilus or whistling, often accompanied by blowing breath sounds.

Added sounds may be heard behind as in front, and possess much the same significance. The fine, sparse crepitations described on page 242, and occurring with early disease, may sometimes be heard at the bases behind. When a definite lung infiltration has reached the surface, this occurs not infrequently at one or other

base. In this situation it may have to be diagnosed from bronchiectasis (see p. 83 *et seq.*), and in young children from broncho-pneumonia. In the latter disease the area of distribution, generally at both bases, the absence of signs of glandular disease, the more notable respiratory disturbance, and the acuter nature of the illness, generally suffice to determine its nature.

Not infrequently a simple bronchial catarrh is found as an accompaniment of glandular and hilus tuberculosis in childhood. It possesses no character peculiar to these cases, and it is presumably dependent on the defective functions, particularly drainage, of the diseased broncho-pulmonary glands.

CONCLUSIONS

To sum up shortly the physical signs of hilus tuberculosis in children, we may indicate the following points as those likely to be of value in its diagnosis.

Disease of Glands

Tracheo-bronchial glands. Wide parasternal impairment, fulness of chest veins, and perhaps of jugular and temporal veins, enlarged supraclavicular glands. Loud blowing breath sounds at right apex, and down the spine, indicating enlargement of these, or of lateral tracheal glands.

Bifurcation glands. Right paravertebral impairment, together with slight 'contrast impairment' over right lung, most marked at apex behind.

Broncho-pulmonary glands. Paravertebral impairment, for the most part double.

Disease of Lung

The reflex bands of impairment (Fig. 3, p. 35, also Fig. 29) as evidence of definite lung involvement. Apart from this there is no sign which denotes the presence

of deep lung disease; only when such disease has reached the surface at some point, in other words is advanced, do stethoscopic signs of lung infiltration make their appearance.

Thus in the diagnosis of hilus tuberculosis we look for evidence of glandular disease, and for knowledge of the lung involvement we need to turn, for the most part, to the X-rays, and to the symptomatology.

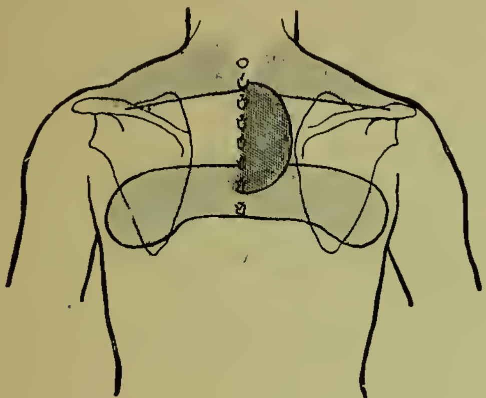


Fig. 29.—Right paravertebral dulness, together with the reflex bands of impairment which indicate accompanying pulmonary disease.

SPINAL SIGNS

The natural expectation that valuable evidence of enlargement of tracheal and bifurcation glands would be reached through examination of the vertebral spines has not been altogether fulfilled. Three methods of examination require mention :—

Percussion. The results of this vary both in health and disease according as percussion is immediate, that is directly onto the vertebral spinous process, or mediate, with a pleximeter, generally a finger of the other hand, between. In the healthy, immediate percussion discovers relative impairment of the upper spines, often

less marked on the third and fourth than above, and relative resonance of the fifth spine. Mediate percussion, on the other hand, gives relative resonance of all spines except the fifth.

In counting the spinous processes difficulty is sometimes felt in deciding between the seventh cervical and the first dorsal, since the latter is not infrequently the larger of the two. The matter is readily decided by fixing the upper limit of the lung by percussion (see Goldscheider's method, p. 66), since this corresponds, apart from gross disease, with the spine of the first dorsal vertebra.

It is clear, then, that whether to mediate or immediate percussion, the fifth dorsal vertebra stands out by contrast in the healthy. This is important to remember, since the anatomical relationships of this vertebra make it the main point of inquiry in disease. For the trachea bifurcates at the level of the third and fourth spines, and the fifth lies below the bifurcation and over the bifurcation glands (see Fig. 30). In cases of enlargement of these it might be expected, therefore, that some change of the normal percussion resonance would occur, and this has been often claimed. Stoll states that dulness over the fifth and sixth spines is abnormal and a sign of tumour formation, and De la Camp thinks an increase in dulness over these spines very valuable evidence of bronchial gland disease. It was present in one-third of his cases. Nagel found experimentally that 15 c.c. of paraffin injected at this point caused definite impairment, but that 10 c.c. was not sufficient for this. In one subject chosen for injection impairment over the fifth and sixth spines was discovered to be already present, due, it was found, to the presence of enlarged and anthracotic bifurcation glands.

It does not seem clear from the account of these

observers what form of percussion they used or, indeed, whether they were thoroughly familiar with the normal conditions. The writer himself has failed to obtain evidence of value from spinal percussion. As a rule but little, if any, change from the normal is observed in cases where other signs point to enlargement of

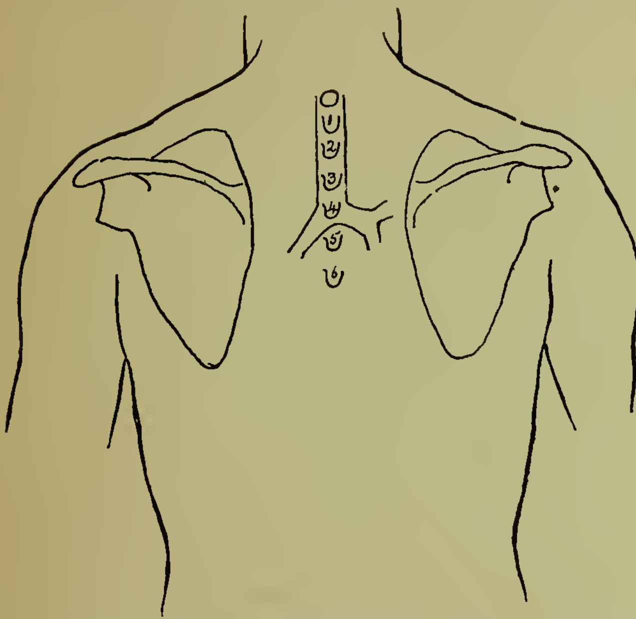


FIG. 30.—Diagram showing the Relationship of the Vertebral Spines to the Trachea and Bronchi.

glands. This is not strange when it is considered how large a mass Nagel's 15 c.c. of paraffin would represent. The writer can well believe that definite changes in resonance and even in resistance, might be appreciated where such tumour-like masses were present.

Auscultation. Spinal auscultation seems to the writer of somewhat more value than percussion. D'Espine, the apostle of this method, auscultates the voice and

breath sounds over the seventh cervical and first dorsal vertebræ, and finds, in cases of disease, a whispering echo added to the voice sounds, and tubular breathing here and sometimes down to the fourth or fifth spine. He also describes spinal dulness when the glands enlarge still further.

It must be remarked at once that, at any rate, the seventh cervical and first dorsal spines can give no evidence indicative of glandular disease. From examination of large numbers of healthy children the writer has assured himself that tracheal breath sounds and associated bronchophony are always present over the seventh cervical and often over the first and second dorsal spines. Below this point the sounds vary greatly: in some modified tracheal breathing is continued down the spine, becoming gradually less and less and lower pitched; in others this type of breathing stops abruptly below the first or second dorsal spine. Reliance can only be placed on this sign when tracheal sounds are strikingly conducted over the fourth or fifth spine, whether present or not over the spines above this point. When limited in this manner the sign is not commonly present, and is better appreciated by breath than voice sounds. Its value is very inferior, as evidence of glandular enlargement to the parasternal and paravertebral dulness described on earlier pages.

It may be here remarked, incidentally, that crepitations at the end of inspiration are commonly heard over the spine in health. They appear to be atelectatic in origin and are of no significance.

Pressure on the spines with the thumb with a view to eliciting tenderness (spinalgia) was recommended by Petruschky and others; in the writer's experience such tenderness is uncommon and when present of doubtful significance. The child is placed sideways and the expression watched while the spines are firmly pressed

from above downwards with the thumb; the fifth spine, corresponding to the bifurcation glands, is said to be most commonly tender. Significance is also attached by some to depression of one or two vertebræ below the general level, but this, in the writer's experience, is common enough without glandular disease.

PRESSURE SIGNS AND SYMPTOMS

Such pressure signs as are commonly observed with tuberculosis of thoracic glands—enlargement of veins, pulmonary collapse, and the like—have been already described. Certain prominent symptoms, moreover, such as cough and pain, dependent largely or entirely on the irritation or compression of nerve-endings and perhaps other structures, appear more conveniently under other headings. These apart, there remain certain signs and symptoms which may appear in cases where the glands reach tumour-like proportions. Such cases are rare, and mostly occur in infancy, when enlargement and caseation proceed rapidly and where the thoracic cavity is relatively small. The manner of their production will be best understood by reference to the brief section on the anatomical relationship of the intrathoracic glands (p. 227). It must not be forgotten that other diseases than tuberculosis may cause, as in the neck, considerable swelling of glands and might thus give rise to pressure symptoms. More especially is this likely to accompany the catarrh associated with pertussis, measles, and others of the infective fevers.

Air passages. Pressure on trachea or bronchi is rare in older children and implies an impending perforation. In infants it may lead to expiratory dyspnœa, accompanied by an audible expiratory wheeze and some amount of retraction of the chest wall on inspiration. Schick described thirty-six such cases, mostly due to pressure on the right bronchus. Feeble breath sounds and diminished voice conduction will be present over a side; there may be râles, or rhonchus audible at a distance and persisting at the same spot.

Blood-vessels. Veins. Pressure on the vena cava or either innominate vein may cause enlargement of veins, cyanosis, and puffiness over the head and arms. Epistaxis is said to occur. Pressure on the azygos vein has been already described (p. 233). Pressure on the pulmonary veins is said to lead to pulmonary œdema or hæmoptysis.

Arteries. Of these the most important are the right pulmonary trunk which runs in close relationship to the bifurcation glands, and the smaller branches occupying the angles of division of the bronchi and thus liable to compression by the broncho-pulmonary glands. Their obliteration leads to pulmonary collapse (pp. 246, 247). Pressure on the innominate artery is said to reduce the size and rapidity of the pulse.

Nerves. Vagus and recurrent laryngeal. The most important result of pressure on the vagus and its branches is cough; its manifold varieties have been already outlined. It will be remembered that the vagus is not a sensory nerve below its superior laryngeal branch. Its irritation cannot, then, directly lead to cough, but must do so by setting up a hyper-irritability of the nerve centre, which is referred to the superior laryngeal nerve as the only sensory branch. In addition to cough, vomiting may occur, whether associated with it or occurring independently. Dyspnœa and attacks of asthma, which are very prominent symptoms in infancy, may depend either on nervous interference or on direct pressure on the larger air tubes. In addition, slowing and acceleration of the pulse, and cardiac dilatation are said to be caused by pressure on the vagus in some cases. Paralysis of laryngeal muscles may occur, especially on the left side, where lateral tracheal glands are often found adherent to the recurrent laryngeal nerve, and may lead to raucous voice and clanging cough. Pressure on the phrenic is said to cause dyspnœa, and on the sympathetic nerve, dilatation of the pupil.

Œsophagus. Pressure on the œsophagus might lead to dysphagia, or pain on swallowing. The bifurcation gland sometimes becomes adherent and empties its

contents into the œsophagus, leaving a permanent fistula.

We have already remarked that these pressure signs and symptoms belong especially to infancy and the first few years of life. At these ages glandular enlargement tends to be excessive and of rapid production, while the smaller parts allow less room for their increased contents. In older children disease is of chronic course and fitful development, and tuberculous glands remain of strictly moderate dimensions. Thus it happens that glandular and hilus tuberculosis gives a different picture in children of the first and second dentition. In the first, it is often a striking portrayal of acute and intermittent symptoms, asthmatic attacks, expiratory dyspnœa, characteristic ringing or spasmodic cough, with signs, in some cases, of marked pressure; in the second, a picture of chronic wasting disease with few and inconsiderable symptoms, and with signs due to slight but prolonged interference with the paths of communication near which the diseased glands lie.

In the following pages will be illustrated the general aspect of tuberculosis as it appears in children of school age, and also as it commonly shows itself in infancy and early childhood.

GENERAL ASPECT OF TUBERCULOSIS IN CHILDREN OF SCHOOL AGE

Between the ages of five or six years and puberty, resistance to tuberculous disease appears to be at its highest level. Progressive and fatal tuberculosis is uncommon, and, if disease does become clinically evident, it is usually of limited extent or activity, and very readily recoverable. A gradual onset with loss of flesh or failure to gain and, as a rule, cough, are the usual points elicited in the history. The child to inspection appears thin, pale, tired-looking, cough is dry and hacking, or it may be so slight as to pass unnoticed. Examin-

ation shows a blue network of veins over the chest, somewhat full jugulars, and perhaps one or two pea-sized glands above the inner end of the clavicle on one or other side. Since these are evidences of tracheo-bronchial enlargement it is usual, in such cases, to find a widened parasternal dulness on careful mapping out of this area. But the signs of venous obstruction may be present without any recognisable increase of dulness.

Contrast percussion will demonstrate a slight impairment, shown by a rise of pitch to gentle percussion, over the right side, and this will generally be found behind also. Examination of the back will show right paravertebral dulness, the commonest of all the signs of glandular enlargement; in cases where disease is of long standing a similar, but smaller, paravertebral area of impairment may be demonstrable on the left side also. Breath sounds may be loud and blowing at the right apex — evidence, probably, that the lateral tracheal glands are affected, and only very rarely pointing to a lung infiltration. In the same children stethoscopic spinal signs (p. 251) are not infrequently present. Both blowing breath sounds and spinal signs are more commonly absent than present. At the bases in front, and sometimes also behind, may be found a few indeterminate crackles or crepitations.

Here we have the picture of a glandular and hilus tuberculosis of limited activity and extent, such as is common in children of school age. Not often do we find evidences of all three varieties of glandular involvement present together in the same chest. As a rule the stress falls on one gland group, commonly the bifurcation glands, giving a right paravertebral dulness alone, for a time at least; parasternal impairment is generally more evident in children of younger age.

So much for the common picture presented by intrathoracic tuberculosis in children of school age. Some-

times these signs are present in association with some other tuberculous manifestation, such as pleural effusion, or some variety of surgical tuberculosis.

A condition which tends to closely simulate hilus tuberculosis in its general aspects is the **chronic gastro-intestinal catarrh** of childhood. The patient is generally thin and pallid with dark-ringed eyes, languid, of capricious appetite, and of irritable temper. The appetite varies, is either ravenous or absent; the bowels are alternately costive or loose, and the stools often contain mucus. These children are commonly of unstable nervous type, and often qualify for the title of 'neurasthenics.' Dingwall Fordyce has pointed out that they possess a diminished power of dealing with fats, whereas the tubercular child can usually digest a good quantity, in the form of codliver oil or otherwise, without difficulty. The diagnosis depends in the main on the absence of all signs of active tuberculosis.

Hilus tuberculosis at school age is generally very amenable to hygienic-dietetic measures, and quite moderate treatment suffices to turn the scales on the side of recovery; the general condition improves, symptoms vanish, though the signs of glandular enlargement persist over a long period. Occasionally, however, even at school age, tuberculosis becomes progressive and spreads out to the periphery of the lung, and by the time it has reached the surface disease must be labelled 'advanced.' For limited surface signs correspond, in these cases, with widespread deep disease, as a radiogram will readily reveal. When disease advances in this manner it will generally reach the surface first about the middle of the lung in front, or in the axilla, or at the base behind, just as in hilus tuberculosis of the adult (p. 95). Close-set crepitations of a moist character, together with a somewhat blowing quality of breath sounds, are the signs which then appear under the stethoscope.

Occasionally, in children of seven years or over, and more commonly the nearer puberty is approached, cases of apical phthisis begin to make their appearance. Definite signs of tuberculous infiltration develop at one apex, and the disease tends to advance rapidly to cavitation. These cases are of more active spread and serious outlook than hilus tuberculosis; for their early diagnosis the reader is referred to Part I of this book, where apical phthisis in the adult, with which they are closely similar, is set forth in detail.

GENERAL ASPECT OF TUBERCULOSIS IN INFANTS AND YOUNG CHILDREN

In infants the symptoms may be of gradual development, or come in the wake of a gastro-intestinal disturbance—in children just above the age of infancy an attack of measles or whooping cough, whether with or without broncho-pneumonia, very commonly determines the onset. The main symptoms, as in the previous group, are generally wasting and cough, but the latter, though often short and dry, may also present the characteristic features of glandular pressure in its spasmodic, ‘ brassy ’ or rattling character. Dyspnœa and expiratory stridor may also, though rarely, be a striking feature, and simulate asthma, save that the obstruction is permanent, though liable to exacerbations. Where these symptoms are present and marked, the child may show a dusky swelling of the face, the jugulars and chest veins may be prominent, and signs of tracheo-bronchial enlargement prove very evident to physical and radiological examination (see Pressure signs, pp. 255, 256).

In cases where these evidences of gross glandular swelling are absent, the child will show wasting and pallor, and,

often, those changes in cutaneous structures generally designated 'scrofulous.' The skin will appear dry and harsh, the hair colourless, the eyelashes of unusual growth, and the body hair abundant and downy, especially over the back. These changes, though they denote a chronic bacterial infection; are by no means pathognomonic of tubercle, but are equally to be found, as Cornet first pointed out, in prolonged disease of pyogenic causation. The writer has seen them very well marked in protracted broncho-pneumonias, and also in neglected empyemas. In tuberculous infants multiple shotty glands will often be found in the posterior triangle on one or both sides, and are of decided significance. Enlarged superclavicular glands, and perhaps shotty intercostal glands, may also give evidence of intrathoracic disease. In addition it is not uncommon for subcutaneous tuberculous nodules to appear here and there, and to soften and involve the skin.

The chest signs in these children vary widely in different cases; evidence of their tuberculous nature must be derived from signs of intrathoracic glandular enlargement, particularly in wide parasternal dulness, shotty supraclavicular glands where these occur, and, in infants, often a large firm spleen, and shotty mesenteric glands, palpable just to the right of the umbilicus, and sometimes ascites, a most valuable confirmation when clearly present. A radiogram may reveal isolated or conglomerate tubercles.

In addition to the signs of enlarged intrathoracic glands, often the sole evidence of disease in the older group (p. 258), infants and young children very commonly present signs of disease at some point on the surface of the chest. Impairment may be found over the whole or part of one lung, often the scapular region on the right side. Evidences of pleurisy are not infrequent, particularly in infants, when a miliary

tuberculosis of the pleura may occur giving impairment over the whole of one side, with some feebleness of breathing, and perhaps fine friction. Ghon pointed out how frequently a pleurisy accompanies the development of the primary lung focus, either as a pleural tuberculosis, or still more commonly as an adhesive pleuritis. In the latter case localised friction, and perhaps impairment, may be detected, and a ground-glass shadow be manifest on the X-ray plate. Simple bronchitis may be present in the chest, or true lung signs appear, as crepitations over some spot, often the right back below or above, or over the whole side, or at both bases. These signs at their first appearance are often curiously inconstant, this perhaps depending partly, but certainly not entirely, on the opportunity the child gives for examination.

Care must be taken, in children recovered from broncho-pneumonia, especially if associated with measles or whooping cough, that the basal crepitations of bronchiolectasis, so common a sequel to these attacks, are not mistaken for the signs of tuberculosis. In cases where evidence of glandular enlargement is present in these cases, it must always be extremely difficult to decide on the nature of basal crepitations. This difficulty is increased by the fact that recovered tuberculous lung infiltrations in children often leave behind, as in adults, the signs and symptoms of dilated tubes. When this final bronchiectatic, or bronchiolectatic stage is reached, it may be very difficult to decide whether the condition was not bronchiectatic from the outset, and to convince others that there had ever been a tuberculous stage to the illness. So much prejudice is there against the actuality of recovering lung tuberculosis in young children.

The picture of signs and symptoms presented above belongs to glandular and hilus tuberculosis, generally

of caseous broncho-pneumonic type, as it occurs at these early ages. Sometimes a miliary tuberculosis may be present, either of 'pulmonary' type, when acute broncho-pneumonia is simulated, or, in young infants, of 'marantic' type, with prolonged wasting, and little or no lung signs or symptoms. In these latter cases the child wastes steadily, is quiet and subdued, presents no definite gastro-intestinal disturbance, nor appears to have started with such; on the X-ray plate appear the shadows of the large, white or yellow tubercles characteristic of the chronic type of general tuberculosis.

It is in this age group, namely in infancy and up to four or five years of age, that the radiogram is of especial value in the diagnosis of tuberculosis (p. 265). In infants, particularly, the chest signs may be absent or doubtful at a stage when the X-ray plate already gives clear evidence of disease, and even in cases where the diagnosis is fairly certain, the radiogram will provide valuable information as to the nature, distribution, and extent of the tuberculous process. A general anæsthetic can usually be given with safety where a plate cannot be otherwise obtained, but this is not often necessary in practice.

THE SPECIAL DIAGNOSTIC TESTS

RONTGEN RAYS

The value of radiology in the diagnosis of tubercle may be said to increase steadily as we glance down the years in the direction of infancy. In the elderly and old the X-ray plate is, of necessity, scored with the marks of past disease; in the infant, on the other hand, whatever abnormal shadowings appear, these may safely be accepted, without further demur, as recent and active. Hence, in the infant, and in the young child up to school age, the radiograph is often of supreme value in deciding on a 'doubtful chest,' and during school years it remains, if not equally serviceable, still often of decided utility, and always of absorbing interest. For the lungs of school children living among crowded communities generally exhibit abundant evidence of tuberculous disease, both healed or quiescent, and also, not infrequently, in a state of still smouldering activity.

Among sixty-one such children, aged five to eleven years, from schools in one of the poorest districts of London, examined by the writer in conjunction with W. Overend, it was found that practically all showed evidence of tubercle to X-ray examination, and a very large proportion to careful clinical examination also. Nearly two-thirds of these cases were members of tuberculous households, but those from healthy families showed nearly equal evidence of disease. Thus among the latter only three chests could be considered strictly normal, presenting, as warrant thereof, (1) translucent pulmonary fields, with good illumination on deep in-

spiration; (2) normal movements of ribs and diaphragm; (3) a radiogram with insignificant hilum capacities with, at the most, only a few radiating peribronchial striæ, accompanied by a trivial number of small and obsolete focal shadows. The remainder all showed evidences of gross disease whether glandular, peribronchial, or pulmonary, or a mixture of these; among 52 per cent. obsolete, but in 35 per cent. giving radiological signs of activity. Among the children from tuberculous households every one exhibited the shadows of gross disease, and the percentage of active disease was still higher. Yet these were all children attending school and, with a few exceptions, free of such symptoms as would suffice to arouse the anxiety of parents or friends. Many were of poor or bad nutrition, but not of such striking nature as to attract attention in a London slum.

Obviously among children of school age a certain amount of tuberculous disease in the chest must be discounted before the need for anxiety arises, and the main difficulty is to estimate how extensive this may be. Obsolete tubercle may be regarded with equanimity; radiological evidences of activity (see p. 273) are certainly reason for frequent revision of signs and symptoms. The latter, of which wasting is perhaps the most striking, must always receive serious attention and be regarded as cause for treatment—signs without symptoms are, on the contrary, of far less account.

In children below the age of five years serious attention must be given to radiological findings, even though symptoms may appear slight or absent at the time of examination. The lungs of normal infants and young children present little or no shadowing on the plate outside the delicate hilus opacity, and, if the shadows of disease appear, this is certain to be active and only too likely to prove progressive in its tendency. Nevertheless, the X-rays have clearly demonstrated that

tuberculous disease of intrathoracic glands and lung may be recovered from, even in infancy, and the writer possesses the clinical notes and radiograms of many such fortunate cases round about the end of the first year of life.

Technique. The technique of X-ray examination is similar in the child to that in the adult (p. 133). If the child's confidence has been gained beforehand, he can generally be persuaded to breathe deeply, in most cases to cough, and also to hold the breath, even up to eight to ten seconds when necessary, while a radiogram is taken. This latter manœuvre is greatly aided by getting him to shut the mouth and breathe through the nose, and by gently but firmly compressing the nostrils while the breath is being held. In infants and young children it is, of course, impossible to obtain a held inspiration, and the radiogram must be, for this reason, as near instantaneous as the apparatus permits. In obstreperous children an anæsthetic may be required, and has never done harm in the writer's experience.

In addition to antero-posterior plates, it is sometimes required to examine and photograph the chest in the right oblique position, so as to reveal, among other points, the condition of the bifurcation glands. For this purpose the child lies on his left side with the left arm under his head, and is then rolled backwards towards the supine position over an air pillow placed against his back and over which his right arm is extended. In this way the posterior mediastium is brought into view, and, on deep inspiration, a wide space appears between the pericardium and spine with its base on the diaphragm below. About the middle of this space the trachea may be seen to bifurcate, and the bronchi can be traced in their further course, the right over the spine, and the left across the cardiac shadow (see Fig. 32, p. 269).

RADIOGRAPHIC APPEARANCES IN TUBERCULOSIS

Glands

The lateral tracheal, and **tracheo-bronchial glands,** when diseased, present a bar of shadow outside and parallel to the sternum, stretching from the clavicle down towards the hilum across the posterior second, third, and fourth intercostal spaces (Fig. 31, p. 268). This shadow is dense, and of convex outline where disease is recent, and may show within it the lumpy rounded shadowings of caseous glands. In infants it may reach considerable dimensions, while in older children it is generally of more moderate size. An oblique illumination shows that the glandular mass projects forward as well as laterally, and it is for this reason that it tends to exert pressure on the superior vena cava. In some cases it may present a thin veil-like appearance with a straight or even a concave border.

Tracheo-bronchial opacities are most readily visualised, and also most often diseased, on the right side; on the left the glands are fewer in number, and an opacity in this situation tends to be confused with certain other structures in this region. Thus the aortic bend—but this is rarely visible in children; the thymus gland, which may present a peaked appearance to the left; a dilated conus arteriosus and left auricle, which lie somewhat below the tracheo-bronchial shadow—all these must be differentiated. Care must be taken, also, that the sternal shadow be not mistaken for tracheo-bronchial opacities in cases where its edge, owing to accidental obliquity of the pose, falls outside the mediastinal shadow on one or other side; the position of the sterno-clavicular joints should serve for the avoidance of this possible error.

Double tracheo-bronchial opacity may be simulated by spinal abscess due to caries of cervical vertebræ, and this must be borne in mind. The abscess may usually

FIG. 31.—To illustrate the shadowing of enlarged tracheo-bronchial glands on the right side. The lung disease was here bronchiectatic.

be distinguished by its more circular outline, its greater density and size in many cases, and by the possession of a rounded lower edge crossing the mediastinal shadow or the heart. There will also, in such cases, be signs

and symptoms of vertebral caries, together with absence of the usual parasternal dulness over the front of the thorax.

Enlarged **bifurcation glands** are only clearly visible

Taken by Dr. W. Overend, and reproduced from the Archives of Radiology and Electrotherapy.

Fig. 32.—Right oblique radiogram showing calcareous bifurcation and tracheo-bronchial glands.

when an oblique radiogram is taken (p. 266 and Fig. 32). In this the trachea and its bifurcation should be clearly visible, and also the bronchi as they diverge across the spine and the cardiac shadow. In the angle between them appears the shadow of the bifurcation glands, and this shadow is practically never absent, though its character

may help to determine whether the glands are merely swollen, or caseous, calcareous, or reduced to a fibroid mass. On the whole it may be said that the bifurcation glands are so invariably affected with tubercle, to a lesser or greater extent, that but little help is derived, as a rule, from their X-ray examination.

The **broncho-pulmonary glands** tend to form part of the **hilus shadow**, and may be conveniently considered in conjunction with this. In tuberculosis of the young child the hilus generally appears as a dense, but homogeneous, tongue-shaped shadow with its tip directed downwards; in some cases, and particularly at later ages, roundish shadows of caseous glands may be differentiated within it, or smaller dense, lumpy calcareous masses may be seen. With active disease the hilus glandular shadows appear of cloudy outline, and in acute cases a diffuse infiltration of the tissues immediately round the root may be visible.

In some cases, particularly in young children, and where active disease is present, the hilus shadow may be surrounded by a ring of isolated tubercles, often faint, ill-defined, and of largish size—not uncommonly these are present in the neighbourhood of the upward strands alone.

The large bronchi in, and immediately outside, the hilus shadow tend, just as in adults, to show an infiltration of their walls, and appear as rings, or figures of eight, or as thickened strands running downwards, upwards, and often outwards. Thereby, eventually, a tree-like spread into the lung on both sides may become visible, and this, at a certain stage, may appear to end abruptly, or it may fade into the visible network of the lung outside. In the infant and young child no lung reticulum is usually visible in health, but the pulmonary fields appear transparent and void.

Lung

The **parenchyma of the lung** may be clear, particularly in young infants in the stage of limited disease, or isolated tubercles may be spread in a ring round the root, or in the upper quadrant; or a heavy network

Taken by Dr. W. Overend.

FIG. 33.—Showing active glandular and peribronchial tuberculosis of the right root and to a less extent of the left.

may cover the pulmonary fields, with thick nodular meshes surrounding clear channels. With acuter development of disease the thick strands and the network are seen to split up into isolated shadows, and the lung soon appears filled with rounded discrete tubercles, and with larger broncho-pneumonic shadows of irregular shape and fluffy outline; these tend here and there to

coalesce into denser areas of caseous consolidation, which obscure the ribs, and bulk large like storm clouds in the pulmonary fields. In other cases the lungs become filled with faint, rounded, isolated, but overlapping nodules, the radiographic picture of caseous tubercles.

Taken by Dr. W. Overend.

FIG. 34.—From the same case as Fig. 33, eight months later, showing a considerable spread of disease into both lungs, especially the right.

Most of these lung appearances are similar to those that may be seen in cases of hilus tuberculosis in the adult (p. 122), and considerable disease may be present, and appear to reach even to the periphery, without any stethoscopic signs being detectable at the surface. Cases of acuter type are often to be seen in infants and young children, but seldom among children of school age

in whom disease, though common, is generally of quiet and smouldering type.

The radiographic picture of apical phthisis (p. 126) may occasionally be seen in older children, but it is exceedingly rare under the age of seven years.

Pleura

Not infrequently the homogeneous, ground-glass shadowing of pleurisy may be observed on the radiogram. This is not infrequent in association with the 'primary' focus in infancy, as was pointed out by Ghon—occasionally such focus also may be detected on the plate; in older children a pleurisy, sometimes adhesive, but more often with an effusion, may be found associated with quite limited glandular and peribronchial disease.

Evidences of activity. And here it may be appropriate to consider what are the evidences of activity of disease, or its arrest, deducible from a radiographic plate. Only when the clavicle, ribs, and diaphragm stand out plainly with clear outline can the radiogram give useful information on these points. Old and arrested foci possess sharp outlines and dense opacities. When disease is active, the gland shadows appear woolly, their intensity is less, and their margins indefinite; the strands running out into the lung, and especially the upward strands, appear dense, and of nodular indefinite outline. The connecting reticulum at their periphery tends to disappear. There may be a haziness in the pulmonary fields, and the separate foci in them appear blurred and vague.

Note must be made of the fallacy that structures which are out of focus tend to appear diffuse and woolly, and hence to simulate the hall-marks of high activity. The use of a ventro-dorsal in addition to a dorso-ventral plate will sometimes help to correct this false impression.

RADIOSCOPY

Screening is of less utility in children than in adults, owing to the greater difficulty in getting carried out the various manipulations required. Differences of apical brightening are of less value, since conditions of incomplete expansion or collapse are common in the child's lung apart from tubercle. Movements of the diaphragm may be noted with advantage, both front and back in older children, since evidences of pleurisy, recent or obsolete, may be thereby obtained. It was remarked by De la Camp and Köhler that Williams' sign is generally absent with tuberculosis of thoracic glands, but this has not been the experience of the writer. Overend found the appearance of the pulmonary fields under screening to fall naturally into four groups :—

(*a*) The normal with good illumination and clear pulmonary areas.

(*b*) The cloudy and indistinct, with poor illumination, sometimes due to a pleuritic veil, sometimes to congestion of vessels and lymphatics.

(*c*) The granular, in which the areas are studded with minute specks.

(*d*) The cloudy and granular, a combination of (*b*) and (*c*).

THE RESULTS OF X-RAY EXAMINATION

The routine use of the X-rays in the pulmonary diseases of children tends, on the whole, to support the clinician in the accuracy of his diagnosis from physical signs and symptoms. Where the radiogram presents tracheo-bronchial opacities, the physician should succeed in demonstrating an increase of parasternal dulness (p. 240); with disease of bifurcation glands, if this leads to marked enlargement, there will be associated right paravertebral dulness (p. 245), while in association with

strong hilus shadowings, dulness will often appear to clinical examination on both sides of the spine (p. 247).

Only of pulmonary involvement are we left without evident clinical signs to correspond with the X-ray findings, since such disease is, save in its later stages, situated so deep in the lungs as to be quite out of reach of the stethoscope. Nevertheless, disease of the lung parenchyma can generally be deduced, even at its beginning, from symptoms and various collateral signs, and when it reaches the surface at any point the clinical evidence of pulmonary involvement is clear. Since, however, there is little or nothing which is distinctive about the pulmonary stethoscopic signs, it must be, in all cases, on the evidence of glandular involvement that the clinical diagnosis is based. For the tuberculous nature of a case of chest disease in a young child may be fairly safely predicted if it is accompanied by decided parasternal dulness, and strongly suspected where paravertebral impairment is present. To these evidences derived from clinical examination the X-rays, however, may add an additional point in the visualisation of the tubercles themselves. Gross glandular enlargement gives high probability of tuberculous causation, but tubercles, if they are clearly visible, are no less than pathognomonic of the disease.

Thus in the diagnosis of chest disease in young children the X-rays may not only demonstrate the extent of the disease which is present, but give practical proof of its nature. In cases where broncho-pneumonic shadowings are alone discoverable, the evidence of tubercle will, of course, be lacking, since these may clearly be of other and various causation. And this brings us to two important points in the differential diagnosis of tubercle under the X-rays—the diagnosis from simple broncho-pneumonia, and the diagnosis from bronchiectasis.

Simple broncho-pneumonia can generally be recognised by its distribution, which tends to be double and basal, and confined to the lower lobes. Nevertheless, this is more a clinical than an X-ray distinction, since broncho-pneumonic patches may also be visible around the roots, and the diagnosis thus less easy than might be at first expected. Other evidence of tubercle must be looked for, in definite tubercles, gross disease of glands, and peribronchial disease about the root and larger branches.

Bronchiectasis is, again, usually a basal disease, and tends to follow the distribution of the broncho-pneumonia, from which it so commonly arises. Where the larger bronchi are affected the condition may be obvious, and thick tubes and circles be visible in positions where the size of their lumen is clear evidence of dilatation. A bronchiolectasis, or dilatation of the smaller bronchi, may show little or nothing when the tubes are empty, and may present appearances extraordinarily like tubercle when they are full. The distribution, and a sacculated appearance at one or more points, must be relied on in diagnosis, together with failure of evidences of tubercle elsewhere. Where, however, other evidences of tubercle, such as increased tracheo-bronchial opacities, appear, their presence does not exclude a simple bronchiectasis as an accompaniment; moreover, the writer has amply convinced himself that healed lung tubercle in children is commonly followed by bronchiectasis, a sequence which, in the adult, has received general recognition and assent.

TUBERCULIN

During the first few years of life the resistance of the tissues to tubercular infection is small; if the tubercle bacillus obtains an entry clinical disease is very likely

to follow. At this early age, therefore, all we require of tuberculin is an answer to the question, "Has tubercular infection occurred?" and this is obtained by the use of our most delicate tests, the cutaneous, or such similar tests as the intracutaneous, subcutaneous local, and percutaneous tests.

THE CUTANEOUS TEST (von Pirquet)

Technique. The only needs are some undiluted old tuberculin and a scarifier. For this purpose a clean needle or lancet is preferable to the von Pirquet scarifier, since the marked traumatic reaction produced by the latter is apt to cloud the result (see remarks on p. 142). The skin of the forearm is cleaned with ether or alcohol, and two scarifications made a short distance apart. These should be of a depth just short of drawing blood, and if the von Pirquet scarifier is used a moist pink hole should result. Into one of these scarifications a drop of the undiluted old tuberculin is now placed, the excess removed with wool, and the remainder allowed to dry on. The other scarification, made for the purpose of control, is either left dry or touched with 20 per cent. glycerine. When they are quite dry the sleeve is replaced without special covering.

The papule. A positive reaction shows itself by the appearance of a red papule, which histologically has the structure of a tubercle, and which, after attaining its maximum size, dwindles and leaves a pigmented stain. It appears after a definite latent period, from three hours to some days, but is generally well-marked in twenty-four hours, and commonly reaches a maximum size, often 10 mm. in diameter, less commonly 20 or even 30 mm., within forty-eight hours (see p. 145). After this it slowly dwindles till by the end of the week only pigment remains and slight desquamation follows.

Many varieties of reaction have been described, and such terms as 'Active,' 'Premature,' 'Late and Persistent,' and 'Scrofulous' sufficiently indicate their peculiarities. The last occurs in scrofulous children, and consists in the development of small papules of a lichenous nature around the larger central one. Sometimes a 'secondary' reaction occurs in a negative scarification as the result of a positive reaction obtained by repetition elsewhere. The only point to determine about the cutaneous test is a definite answer to the question "Is it positive?" This can only be decided by practical experience of the appearance of positive and negative results. Special attention must be paid to the normal 'traumatic reaction,' which only shows slight redness at the end of twenty-four hours, and the 'negative' result, always difficult to separate from the minimal positive. Von Pirquet considers that all reactions below 5 mm. diameter are best called doubtful, and the test repeated. In the case of a negative test it is generally admitted that a **repetition of the test** after a few days is required to exclude the possibility of reaction.

Value of the test. The cutaneous test tells us whether or not infection with the tubercle bacillus has occurred, and it tells us no more than this. It has the great advantage of simplicity and of nearly perfect safety. It has in certain cases in scrofulous children been the starting-point of phlyctenules and of lichen scrofulosorum, and the papule has on occasion led to a scrofulodermatous ulcer. Such occurrences are, however, extremely rare. It fails in certain cases of tuberculosis, generally with cachexia; after a course of tuberculin; during measles, scarlatina, and other infective fevers; and in acute illness generally. Its special value is during the first two or three years of life, when infection is synonymous with disease, and the question

is wholly the presence of sensitiveness and not its amount. As age advances a positive reaction becomes of less and less value, and by the time school age is reached but little attention need be paid to its presence, but considerable value attaches to its absence. A negative result after two attempts is valuable proof of the absence of tuberculosis, if attention is paid to the causes of failure mentioned above.

OTHER 'INFECTION' TESTS

The percutaneous reaction (Moro and Dogonoff), obtained by the inunction of a tuberculin ointment, has the same significance as the cutaneous reaction, but is inferior to it on account of its uncertainty and lesser sensitiveness.

The intracutaneous test was discovered by Mendel, but is associated with the names of Mantoux and Roux who brought it into prominence as the "intradermal reaction." Injection is made into the substance of the skin itself. Engel injects very shallow, so that a bleb is formed; he uses dilutions of 1 : 1,000, 1 : 100, and 1 : 10 in series. Others inject deeper into the skin. The test is extremely delicate, and may be used where the cutaneous test fails. Its disadvantage is the difficult technique and the fact that reaction is distinctly painful. It has proved valuable in testing the result of inoculation experiments on guinea-pigs.

The subcutaneous local reaction (*Stichreaktion* of Escherich) was first described by Epstein in 1901, given a name by Escherich, but by neither looked upon as a specific phenomenon. Its specific nature was pointed out by Schick. It depends on the injection under the skin of quantities of tuberculin too small to elicit a general reaction. The resulting local hyperæmia gives a test too delicate to be of value in adults, but suitable

to indicate 'infection' in childhood. Reuschel uses a 1 : 2,000 dilution, of which 0·4 c.c. are injected. Hamburger employed it to reinforce the results of the cutaneous test, and obtained reactions to 0·0001 or 0·001 c.mm., but gave doses rising as high as 0·1 and 1 c.mm. and thus high enough to give a general reaction in certain cases. The advantage of the method is that reactions can be obtained in cases of active tuberculosis where the cutaneous test is liable to prove negative.

THE QUANTITATIVE CUTANEOUS TEST

The test of Ellermann and Erlandsen, already described in Part I of this book (p. 139), may be applied to children with a view to discovering the amount of their skin sensitiveness. The utility of the test will depend on the significance of such skin sensitiveness in children, and our knowledge of this is, unfortunately, but scanty at present.

The writer knows of no observations with Quanti-Pirquet on children except a certain number carried out by himself. Of first importance is it to discover the amount of tubercular sensitiveness present in normal children, and the writer has examined seven controls on this point. Of these, some of whom were only in their second and third year, but two, aged six and eight years, reacted to tuberculin, and in each case only to the strongest dilution (64 per cent.). From this it appears that sensitiveness is usually low with obsolete tubercle in children.

Among cases of clinical tuberculosis sensitiveness was, as a rule, markedly higher, and varied somewhat according to the type of disease. Thus with tuberculosis of large joints, where a certain amount of autoinoculation is present, sensitiveness was high—over 100 in four of six cases examined. The figures were closely comparable with those commonly obtained in cases of phthisis (see p. 149).

In all the other cases—spinal caries, tubercular peritonitis, and tubercular glands in the thorax and elsewhere—sensitiveness was generally found in the neighbourhood of 50; there was, moreover, far less variation among the figures than among those obtained by the writer in phthisis—but few were very high, and but few failed to react. The numbers are, however, too small to do more than indicate the probable results of a more extensive investigation. We cannot know yet what exceptions there may occur to the low figure common for obsolete tubercle, nor how many cases among a wider material will fail to indicate activity by high sensitiveness. It seems likely that with fairly localised disease in children a steady but moderate figure is maintained, closely in the neighbourhood of 50. If more extensive investigation on controls confirms, with but few exceptions, the low figure obtained by the writer in normal children, the method may be of distinct value in the detection of activity in hilus tuberculosis of childhood.

APPLICABILITY OF THE TUBERCULIN TESTS IN CHILDHOOD

Infancy

During the first three years the cutanous test, performed with undiluted old tuberculin, generally gives all the information required. If it is negative it must be repeated after a few days. If reaction still fails the child may be considered tubercle-free, unless cachexia, advanced or acute disease, or the presence of an infective fever supply the explanation. Under such conditions the intracutaneous or the subcutaneous local reactions described above may be tried.

A positive reaction obtained by any means is a certain sign of infection with the tubercle bacillus, and hence, in children of this age group, of tubercular disease in most cases.

Later Childhood

This is by far the more important group for our present purpose. A large percentage are already infected with tubercle, but knowledge of this no longer provides proof of active disease. The same precautions to separate clinical disease and latent infection have to be taken as in adults, and the means will be closely similar (see pp. 172 and 173). The main difference will lie in the much larger chance of discovering absence of infection than in later years, and so the greater value of the cutaneous test used entirely with a view to a negative result.

Combined cutaneous and conjunctival. These two tests can be utilised simultaneously in the manner already described on p. 155 for adults. The double negative result bears, in the absence of other explanation, the same significance; namely, the absence, with great probability, of active tubercular disease. The double positive also, as in adults, supplies a considerable probability of active disease. Where the tests give a divergent result no reliance is to be placed upon it.

A weaker solution of tuberculin must be used for the conjunctival test in children than in adults, ½ per cent. for the first instillation, and 1 per cent. for a second given in the other eye where the first was negative. In children also especial care must be taken to exclude the 'scrofulous,' and those in whom a former phlyctenular conjunctivitis, or recent redness of conjunctiva or lid, has occurred. Undiluted old tuberculin should be used for the cutaneous test.

Subcutaneous test. This test, applied with half the dosage recommended for adults but otherwise in a similar manner (p. 157), may be used with advantage in childhood, and the results are open to somewhat similar interpretation. More often, however, the use of

this test is excluded by the presence of fever; the striking mobility of the temperature in childhood not only supplies a common contra-indication, but also makes the result of the test more difficult to interpret. Holt, with a wide experience, concluded that a temperature of 102° F. was needed to decide a positive result. Great caution must, however, be used in the repetition of injection after doubtful rises, for harmful focal reactions can be produced in the child even more readily than in the adult.

For the dangers associated with subcutaneous tuberculin the reader is rcferred to the discussion on this point in the first half of the book (p. 170). There also the interpretation of results, closely similar in children and adults, has been considered in some detail (pp. 166, 172).

Differential Cutaneous Test

With a view to differential diagnosis between human and bovine infection Détre introduced the use of a cutaneous test to human and bovine tuberculin simultaneously. The test depends on the presumption that a larger papule will develop to the autonomous strain of tuberculin, and thus indicate the kind of bacillus responsible for the lesion. If this postulate be accepted, however, there still exist so many technical fallacies (see pp. 144 to 146) that but little reliance can seemingly be placed on the method. This view is borne out by the high improbability of the results it has so far exhibited. Détre himself found that 9 per cent. of cases of phthisis were due to the bovine bacillus alone, and 19 per cent. to organisms of both human and bovine strain; and the results of other observers, such as Clarke and Forsyth, and Hamman and Wolman, have been fairly in accord with this. In view of the general agreement of bacteriological investigators as to the almost exclusive presence

of the bacillus of *Typus Humanus* alone in cases of phthisis, such figures can only be taken to prove the futility of the method. Even if the test were reliable the value of performing it would at the present time be purely academic. It would supply no indication for treatment, for there exists no jot of evidence at present that any different curative effects follow the use of homologous than of heterologous tuberculin.

THE TEMPERATURE

The Normal

We have seen (pp. 177 to 181) that the normal temperature in adults is difficult to fix; still more is it a fluid quantity in the child. At the beginning of life the adjustment of the body heat is admittedly imperfect; Jürgensen in experiments on the new-born found that fluctuations of temperature were continuous, and bore no relation to the time of the day; nor was the mean a fixed quantity from day to day as in adults. Thus 35·27°, 38·15°, 38·7°, 38·41°, 38·22°, 37·98° C., represented the mean temperature on a series of days. In addition, higher temperatures than occur in adults were frequently observed: as 38·8° C. (101·8° F.), 39·2° C. (102·5° F.), and even 39·8° C. (103·6° F.), all rectal, in quite healthy infants. These fluctuations settle down by degrees, and the temperature curve gradually approaches more nearly the regularity of the adult standard in course of time. Nevertheless, the striking mobility of the temperature throughout childhood is a well-recognised phenomenon, and such slight causes as dentition and the like may lead to well-marked fever.

When the delicate nervous adjustment necessary to maintain an even temperature is borne in mind, it is hardly surprising that it should be readily upset. This

occurs not only in childhood, where perfect control has not been reached, but also during convalescence from fever, and in women, and neurotics where the mechanism is readily disturbed by nervous influences. There is a tendency to overlook this aspect of the question at the present time, and to ascribe to hidden disease fluctuations which are probably often of no account in children. The matter is rendered especially difficult owing to the common presence in childhood of catarrh of various mucous membranes, especially during school life, and also the high incidence of tubercular infection which, though mild and recoverable, may yet lead to periods of fever of varying duration. On this account the normality of any given child, *qua* toxin absorption, is a matter which is always highly difficult of proof. This is especially so where the child is playing the part of a control and the temperature is found to be higher than preconceived ideas of the limits in health appear to warrant.

Moreover, in healthy children, whether in bed or at large, movement is practically continuous during waking hours, so that a 'resting temperature' can hardly be spoken of in the same sense as in an adult. Let us examine such observations on the temperature of apparently normal children as are available.

Infants. The observations of Jürgensen have already been considered. Bärensprung found the rectal temperatures of children in the second week of life between 37·25° C. (99·05° F.) and 37·6° C. (99·68° F.), or a trifle higher than those of grown-up people.

Older children. Finlayson, in 283 observations (rectal) on children between the ages of 20 months and 10½ years (average 5¼ years), found the maximum at 100·2° F. The mean range was as much as 2°–3° F., and thus markedly higher than in adults.

The morning average (7·30–9 a.m.) was 99·41° F.

The evening average (9–12 p.m.) was 97·5° F.

He pointed out that the highest figure is reached earlier in the afternoon than in adults, and that a rapid fall of one to three degrees between 7 and 9 p.m. is characteristic.

Sachs, in a paper read at the International Congress of Tuberculosis, meeting in Washington, gave the results of mouth-temperature observations on 250 normal children as follows :—

AGES 5–10 YEARS.

Morning (9–10 a.m.) : between 99·4° and 100·4° F.
Average 99° F.
Afternoon (4–6 p.m.) : between 97·4° and 100·5° F.
Average 99·3° F.

AGES 10–15 YEARS.

Morning (9–10 a.m.) : between 98° and 100·2° F.
Average 98·2° F.
Afternoon (4–6 p.m.) : between 98° and 100·2° F.
Average 99·2° F.

Mary H. Williams, taking the temperatures (mouth) of 1,000 school children between the ages of twelve and fourteen years, found that the highest percentage fell on the temperature 100°, and the next two highest on 99·8° and 99·6° F. No less than 55·5 per cent. of the children had temperatures of 99·6° F. or over, and these were, in the main, persistent and not temporary figures. Among these children she excludes from normality a truly fearsome number, no less than three-quarters of the total, on account of tonsillitis, pulmonary tuberculosis, and rheumatism, or suspicion of such. Among the remaining 254, presumably normal, the highest percentage showed a temperature of 99° F., but some had mouth-temperatures as high as 100° F.

When we come to inquire how far the figures we have quoted are truly 'rest' temperatures we are met with a difficulty. Finlayson's observations were made on hospital and infirmary children who were about the ward in the day, and he was careful to note that they were subject to no violent exertions. Nevertheless, the morning temperatures were less truly resting temperatures than were those in the evening, since the latter were taken some hours after the children's bedtime. This may account, to some extent, for the striking fall which this observer notes as occurring between 7 and 9 p.m., but not entirely, since in some cases the drop began as early as 5 p.m. Among Sachs's cases no note is made on the question of exercise or rest; he informs me, however, by letter that the children were "following their usual mode of life. They were not rest temperatures."

Mrs. Williams's observations were made in school, and thus are probably to some extent vitiated by the effects of exercise, since it takes close on an hour for the temperature to fall completely after exertion. Owing to the restlessness of childhood the effects of exercise, as I have already said, cannot often be wholly eliminated, and temperatures during waking hours can seldom be regarded as true rest temperatures in the same sense as in adults.

A further point on which information is needed is the question, not quite clear from the material quoted, whether the raised level of temperature persists, and thus constitutes an individual norm, or whether it represents a fluctuation from this. F. E. Wynne in the observation of 1,000 children found 261 with temperatures of 99° F. or over, and of these 112 presented no obvious defect. He notes the duration of the pyrexia, and records "that the temperature had returned to normal on the second day in 179, or 68·59 per cent.

Still above normal on	2nd day in 82, or	31·4	per cent.
,, ,,	3rd day in 55, or	21·0	,,
,, ,,	4th day in 31, or	11·8	,,
,, ,,	5th day in 16, or	6·1	,,

Those cases in which pyrexia lasted longer than the fifth day were all associated with more or less serious defect or definite illness." This appears to be good evidence for the belief that the peculiarity of the temperature in children lies more in a tendency to abnormal fluctuations than to a raised normal line.

Conclusions. We must admit at once that the figures on which we are required to base a normal limit are to some extent vitiated by the effects of exercise, by catarrhs, and by occult tuberculosis. With due allowance for these errors, it yet appears that the normal takes a somewhat higher level and is subject to wider fluctuations in children than in adults. Moreover, the delicate balance of heat production and loss is still under imperfect control, so that fluctuations which would be significant in the adult may often be disregarded in childhood. In individual children where the health temperature is already known the question of fever is easy to answer. These apart, it seems that occasional rises to 100° rectal (or even mouth) may occur, apart from known causation, in health. Sachs, it will be observed, even found 100·2° F. and 100·5° F. mouth-temperatures, but we should not be disposed to accept these as normal figures for resting conditions.

On the whole it seems to the writer clear that a few 'points' must be allowed to childhood both above and below the normal limits for adults (see p. 180). At the same time it is best to place much less reliance on slight rises of temperature in children than in adults, and in all cases to examine carefully into the conditions of rest or exercise, rectal or mouth observation, room

temperature, and the like under which the observation was taken. Distinct fever is a valuable indication, but its absence does not exclude tuberculosis, and the temperature plays, on the whole, a somewhat smaller part in its detection in childhood than it does in adults.

Fever in Tuberculosis

As already noted, there may be tuberculosis without fever. Not uncommon, in cases of fairly chronic disease,

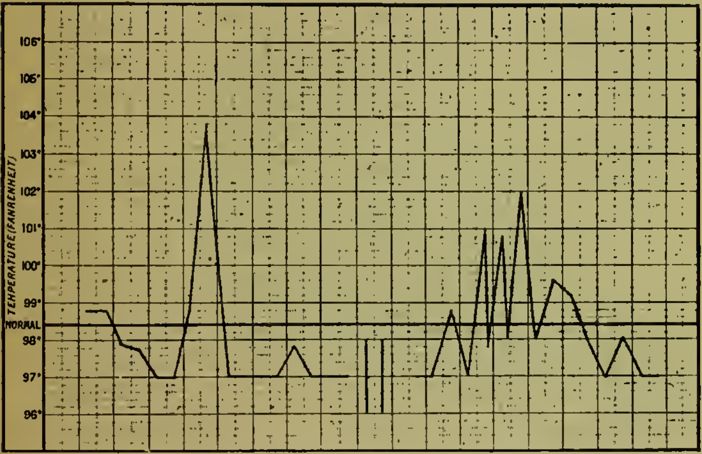


FIG. 35.—Chart showing sudden and unexplained febrile attacks breaking the course of afebrile tuberculosis in childhood.

is an occasional 'notch' of fever (see Fig. 35) occurring as an occasional and unexplained phenomenon in the course of a long sequence of even temperatures. Such apparently causeless rises must be ground for suspicion. Finlayson thought the distinctive point in the temperature with this disease was the replacement of the normal evening fall by an evening rise. The average of a number of observations in tubercular children showed the morning 99·64° F. close to the 99·41° F. of

healthy children, but the evening 99·9° F. considerably above the 97·5° F. average for health. Unfortunately, however, these evening temperatures were taken between 7 and 10 p.m., while the control temperatures were for 9–12 p.m., a difference which considerably vitiates a comparison of this kind. He divides tubercular children, *qua* temperature, into three types :—

I. Morning temperature normal : evening rise.

II. Moderate rise of both morning and evening temperatures, with a distinct tendency to evening exacerbations.

III. Both abnormally high, with exacerbations bearing no constant or obvious reference to time of day.

Sachs remarks also on the characteristic afternoon rise accentuated in many cases with a morning fall, and hence a greater fluctuation. In some cases periodic 'waves' of fever occur.

Ages 5–10 Years.

Morning (9–10 a.m.) : between 97·6° and 99·6° F.
Average 99·7° F.
Afternoon (4–6 p.m.) : between 98·2° and 101° F.
Average 99·7° F.

Ages 10–15 Years.

Morning (9–10 a.m.) : between 97° and 99·6° F.
Average 98·4° F.
Afternoon (4–6 p.m.) : between 98·8° and 100·4° F.
Average 99·5° F.

These figures, all mouth-temperatures, should be compared with those already given by this observer for healthy children (p. 286).

THE SPUTUM

It is but seldom that sputum can be obtained from children; it is almost invariably swallowed. When it has been procured, moreover, it is but rarely, save in children of older age with advanced disease, that the tubercle bacillus can be found in it. This may be perhaps explained, in the cases under consideration, by the tendency of the disease to spread along the framework of the lung in such a manner that only in later stages does it ulcerate into the air passages and become an 'open' tuberculosis. In young children sputum may be obtained sometimes after the manner recommended by Holt—tickling the pharynx with a piece of muslin held in a pressure forceps and, during the resulting paroxysm of cough, wiping up the secretion for investigation. By this means Holt was able to demonstrate the tubercle bacillus in fully 80 per cent. of cases of lung disease in young children, an amount of success which does not appear to have been yet attained by others.

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